THE MODERN MOTOR ENGINEER

A PRACTICAL WORK ON THE MAINTENANCE, RUNNING, ADJUSTMENT, AND REPAIR OF AUTOMOBILES OF ALL TYPES, AND ON THE MANAGEMENT OF GARAGES

BY

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CHAPTER I

AUTOMOBILE ELECTRICITY PRINCIPLES

THE electrical system of a motor vehicle is a fairly complicated arrangement of circuits and accessories that is called upon at the driver's will to perform a number of different tasks or functions. It must provide a constant source of electrical supply for starting the engine, operating the ignition system, illuminating the various lights, e.g. the headlights, side and tail lights, brake-warning and other lights, as required. In modern cars it is often called upon to supply current for miscellaneous items of equipment, e.g. the car radio, window winders, cigarette lighter, for petrol-level gauge operation, and interior air conditioning. In certain recent cars it has also to provide the electrical energy for operating the clutch, " magnetic " brake, and sometimes for gear-changing purposes in automatic transmissions.

In addition to all these demands, it is necessary for the electrical system to supply this electricity at a constant voltage, namely at 6, 12, or 24 volts, according to the type and size of motor vehicle, and to be prepared for a wide range of electrical demands at all times. Thus, it must be so designed that there is always available ample energy at a constant voltage without any falling off of the power under the conditions of maximum demand.

In the case of a modern car, the electrical system must be flexible enough to provide the large amount of energy required for starting the car in cold weather with the side and tail lights, and also for the ignition, lighting, and interior heating (electric-motor-driven fan). On the other hand, it should still be able to supply the relatively small amount of current for the side and tail lights when the car is parked at night at the same constant voltage or for the ignition system for the engine to run " idling " in the daytime.

The automobile electrical system must also operate under severe conditions of road and engine vibrations, at relatively high temperatures for the units and cables under the engine bonnet, and at low or frost temperatures, as when starting or operating, initially, under cold-weather conditions. Further, none of its components should be affected by the presence of moisture.

The complete system is in some respects similar in its basic principle to that of the *town electrical installation*, in which the power derived from the chemical energy of the coal is converted, by the steam engine or turbine,

into mechanical energy at the engine's output shaft. This energy is employed to operate the dynamos or generators, which thus convert the mechanical energy into electrical energy. Finally, when the electricity supply of the town, maintained at a constant voltage, is under demand for purposes such as heating, lighting, operating electric motors, solenoids, and various other electrical appliances, this electrical energy is largely converted into heat energy, which is dissipated to the atmosphere and earth, and is entirely lost so far as any further useful purpose is concerned.

In the case of *automobile electrical plant* the chemical energy of the petrol, or other fuel, is converted into mechanical energy by the combustion process and the utilisation of the gas pressures thus generated. This mechanical energy is largely employed for driving the car or other vehicle, but a small proportion is " tapped off " to drive the dynamo, i.e. it is converted into electrical energy (Fig. 1). The latter is employed to maintain

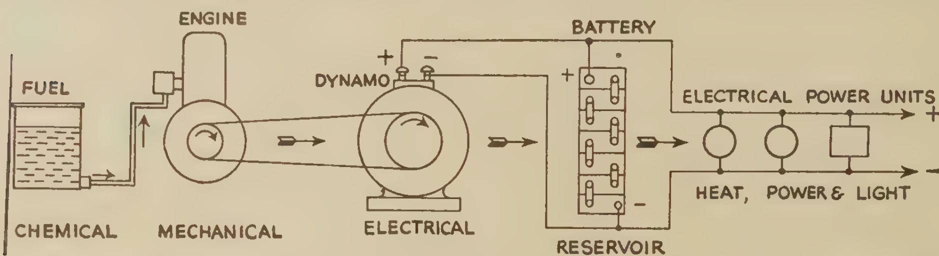


Fig. 1.—Illustrating Conversion of Fuel's Chemical Energy into Mechanical and then Electrical Energy.

a reservoir of electrical energy that can be drawn upon, as required by the driver, for the electrical needs of the ignition, lighting, and starting systems. This reservoir, which is represented by the electric battery, also serves to maintain the supply voltage of the various electrical systems at a constant value under all conditions of engine speed and varying consumption demands. It may here be mentioned that the ordinary shunt-dynamo voltage varies to a large extent with the engine speed, so that it is necessary to provide electrical means for regulation of the voltage; further, at low engine speeds, when the dynamo voltage is much lower than the standard operating or battery voltage, means must be provided for preventing electric energy from flowing back from the battery to the dynamo. This, as will be explained more fully later, is effected by the electrical cut-out unit.

The Hydraulic Analogy

For the benefit of the reader who is not fully acquainted with the electrical principles concerned in automobile practice, reference should be made to the hydraulic analogy illustrated diagrammatically in Fig. 2. In many but not all respects the electrical system is very similar to the water or hydraulic one, in which a steam, petrol, or oil engine E drives a

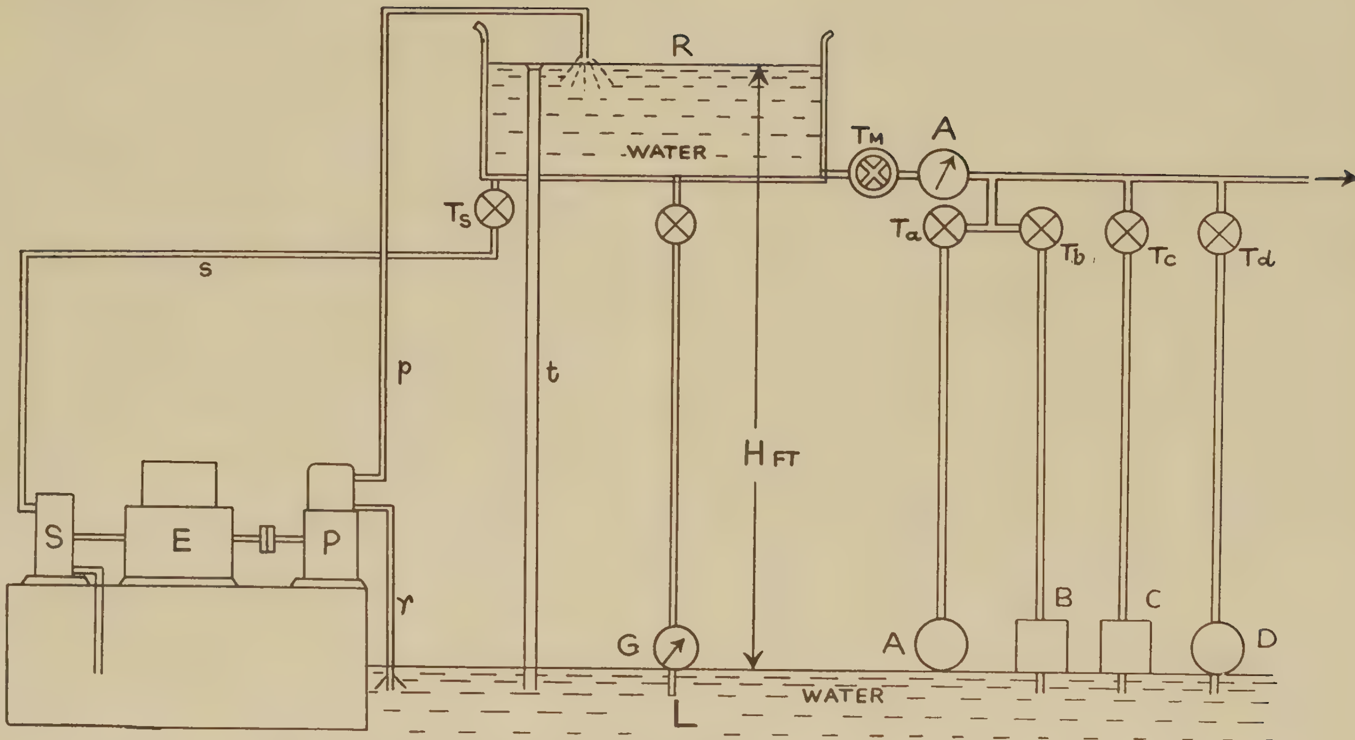


Fig. 2.—The Hydraulic Analogy to th- Automobile and Stat:onary Plant Electrical Systems.

hydraulic pump P, which draws water through the suction pipe *r* from a lower reservoir L and delivers it under pressure along a pipe *p* to a tank or upper reservoir R. The level of the water in R is kept at a constant height H ft. above that of L, by arranging for an overflow pipe *t* having its open end at the desired height H ft. above L. An excess of water that is delivered to the tank R is thus able to flow away to L. We now have a store of water at a constant level, or " head " as it is termed in hydraulics, from which to draw pressure energy for any required purpose; further, this store or quantity of water will constantly be maintained by the engine-driven pump P. The main stop or supply cock is shown at T_M. When it is required to operate any hydraulic component, such as a water turbine, hydraulic tool, machine or other part, A, B, C, D, etc., requiring water under pressure, the appropriate tap, such as T*a*, T*b*, T*c*, T*d*, etc., is turned on, and water under constant pressure, equivalent to the water height H ft., is then delivered to the selected hydraulic components, the water afterwards flowing out to the lower-level reservoir L. The pressure due to the head H ft. is shown by the gauge G; the total quantity of water used is shown by the gauge A. One further example illustrating the use of this hydraulic energy is that of the hydraulic motor S, which is used to start the engine E. When the tap T*s* is opened, the motor S is operated, its "used" water flowing down into the reservoir at L. It should here be pointed out that the actual constant pressure of supply to the various hydraulic components would be reckoned at the level of delivery, and so would be rather less than that denoted by H ft.

Considering now the electrical equivalent to the hydraulic circuit shown in Fig. 2, the various water pipes would be replaced by electric cables or conductors, as shown in Fig. 3. In this case the engine E drives the dynamo P, which delivers electric current along the cable *p* and a voltage regulator *t* to the electrical reservoir, i.e. the battery R. The latter is then the source from which all the electrical supply for the various components, such as A, B, C, D, etc., representing the ignition unit, lamps, and other electrical parts, is taken. The positive output cable of the dynamo is connected to the positive pole of the battery, and the negative to a common electrical conductor, known as the " earth." The voltage V between the positive and negative terminals is always maintained at a constant value by means of the electrical regulator unit *t*; this corresponds to the overflow pipe *t* in Fig. 2. It will be noted that instead of the various taps shown in Fig. 2, electric switches T*a*, T*b*, T*c*, T*d*, etc., are used in the electrical analogy. The amount of current flowing at any time, as shown by the ammeter A in Fig. 3, corresponds to the water consumption meter A in Fig. 2. The voltage-measuring instrument V (Fig. 3) corresponds with the water-pressure gauge G in Fig. 2, and the current or electricity " quantity " meter by the ammeter A, corresponding to A in Fig. 1. Finally, the electric starting motor shown at S derives its electrical supply from the positively connected cable S through the switch T*s*.

These hydraulic and electrical examples should help the reader to

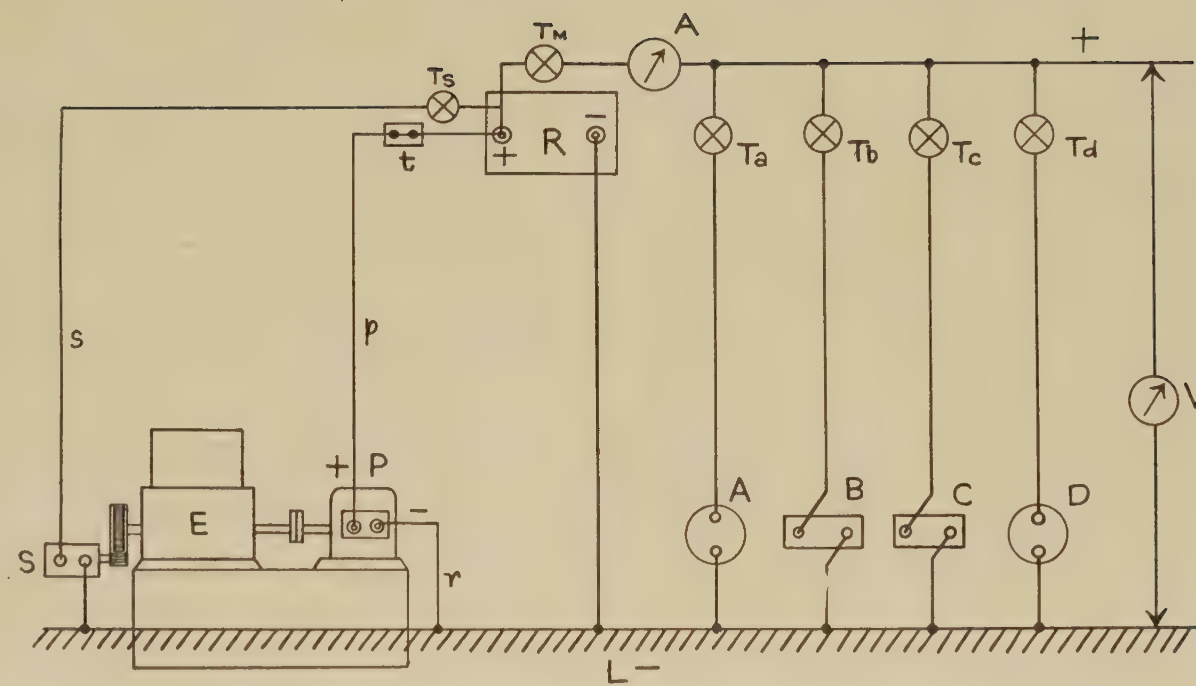


Fig. 3.—Simple Layout of Electrical System, corresponding to the Hydraulic One shown in Fig. 2

understand the general principle of the electrical system of the motor vehicle in so far as it concerns the charging, starting, and lighting (and accessories) circuits, although there are certain features that have not yet been taken into consideration in order to simplify the explanation.

One of these is the ignition system, but since this merely necessitates taking a cable from the positive side of the battery and connecting the negative side of the ignition low-tension or battery supply with the common earth conductor, its omission from Fig. 3 is not a serious matter.

Another feature that has not hitherto been mentioned is the safety means that would be provided in the pressure-supply side of the hydraulic circuit to prevent excessive pressures occurring. It is usual to fit a non-return valve on the pressure side of the pump so that, in the event of excessive pressures occurring, this spring-loaded valve would be forced open and water would escape, thus relieving the pressure. In the electrical analogy, the *dynamo regulator unit* provides against excessive voltage, whilst the *cut-out unit*, on the dynamo output side, prevents current flowing from the battery back through the dynamo when the latter is not working—as when the engine has stopped—or when running at a low speed. The cut-out disconnects the battery from the dynamo under these conditions.

In the hydraulic circuit analogy (Fig. 2), if the pipe *p* were connected to the tank at any point below the upper datum level, denoted by H ft., it would be necessary to fit some hydraulic cut-out device, such as a non-return valve in the pipe *p*, to prevent the water in R from operating or flowing through the motor P. Actually, by arranging the output of *p* above the datum level of the water in R, there is no risk of any flow-back through the motor. One important feature of the electrical circuit is that any excessive electric current that might flow through an electrical component, such as one of the lamps, owing to a short-circuit, is prevented from doing so by the insertion of a *soft metal wire fuse* in the circuit concerned, so that, instead of the excessive current burning out the lamp bulb, it melts the fuse wire and thus breaks the circuit.

In concluding this comparison between simple hydraulic and electrical systems, it may be stated that although the electrical circuit diagrams of modern motor vehicles are much more complicated than the elementary diagram shown in Fig. 3, the basic principles of the various component circuits are identical with that of the latter diagram.

The Four Essential Electrical Circuits

The essential requirements of the automobile electrical system are that: (1) it must provide electrical energy for the various electrical needs; (2) it must maintain this energy at a constant voltage and sufficient in amount for full supply purposes; (3) means must be provided to distribute this energy to each component as required. In some cases the electrical supply is required continuously, as for the ignition system. In other instances the supply demand is intermittent, as for engine-starting purposes.

Again, the demand may sometimes be for relatively long periods, as in the case of the lighting units.

In order to provide for all the various conditions of automobile operation, it is necessary to arrange for four separate electrical circuits, namely as follows: (1) *The Ignition Circuit*; (2) *The Charging Circuit*; (3) *The Starting-motor Circuit*; (4) *The Lighting and Accessories Supply Circuit.*

(1) **The Ignition Circuit.**—The ignition sparks required at each of the engine's cylinders for firing the compressed charge of air and petrol vapour are produced by a type of transformer which receives its electrical supply from the battery and transforms this relatively low-voltage current, i.e. at 6 volts or 12 volts, to the high voltage (4,000 to 16,000 volts) required to produce the spark at the plugs in the cylinder heads. Two different methods are employed on motor vehicles, namely the *Magneto* and the *Battery-and-Coil*, or, as it is better known, the *Coil-ignition System.*

In the magneto method no battery current is used, since the magneto

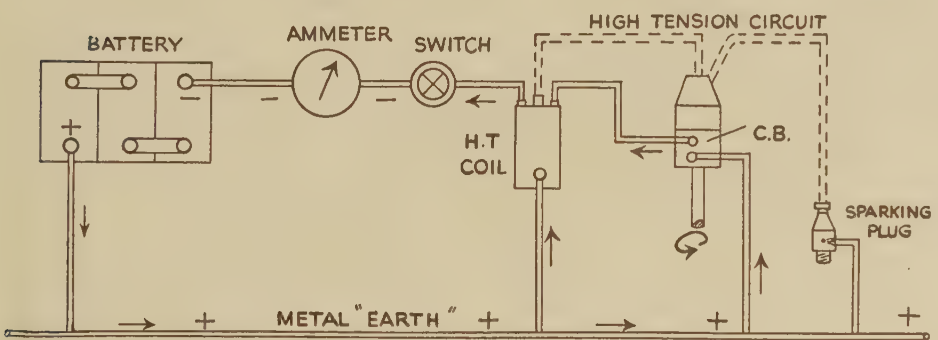


Fig. 4.—Layout of Simple Ignition Circuit for Single-cylinder Engine.

is a self-generating electrical machine, driven by the engine and incorporating its own high-voltage transformer.

In the coil-ignition system the low-voltage (or tension) current is supplied by the battery, and the electrical circuit is entirely separate from the other ones mentioned earlier.

Fig. 4 shows, diagrammatically, a simple ignition-circuit layout for a single-cylinder petrol engine, the various components being indicated on this diagram. The battery negative terminal is connected to the ammeter—which shows the current, but for all the circuits in use—and then to the driver's " on " and " off " switch. Thence to the electrical transformer (or coil) and contact-breaker units, and back to the same common metal conductor as the positive pole of the battery. The arrows indicate the battery-current flow when the switch is " on," and the contact breaker is operated by its engine drive. There is a separate high-voltage (or tension) circuit from the high-tension transformer (coil) through the sparking plug, and thence to the common metal conductor, which is known as the *Earth*.

It will be observed that the coil has an earth connection to complete the high-tension circuit; the latter is indicated by the dotted lines.

In practice, the contact-breaker unit is combined with a device known as the *Distributor*, the purpose of which is to provide the ignition to each sparking plug, in a multi-cylinder engine, at the correct moment near the end of the compression stroke. Even in the case of a single-cylinder engine there is a timing device to ensure the correct moment of sparking at the plug. There are, in addition, other detailed differences and refinements in modern coil-ignition systems, to which further reference is made in Chapter III.

(2) **The Charging Circuit.**—In the preceding considerations it has been shown that the electrical supply for the ignition circuit is derived from the battery. The latter unit stores up electrical energy by a chemical process, and acts as a reservoir from which electricity may be supplied to the various electrical components of the motor vehicle. The battery, however, can only supply current at its normal voltage for a limited period, after which the voltage falls off, until the battery is exhausted and can therefore provide no further electricity. It is necessary, therefore, to employ a dynamo to keep the battery charged, so that its voltage will always be maintained at its normal value. A separate circuit is arranged for this purpose, and it is known as the *Charging Circuit.*

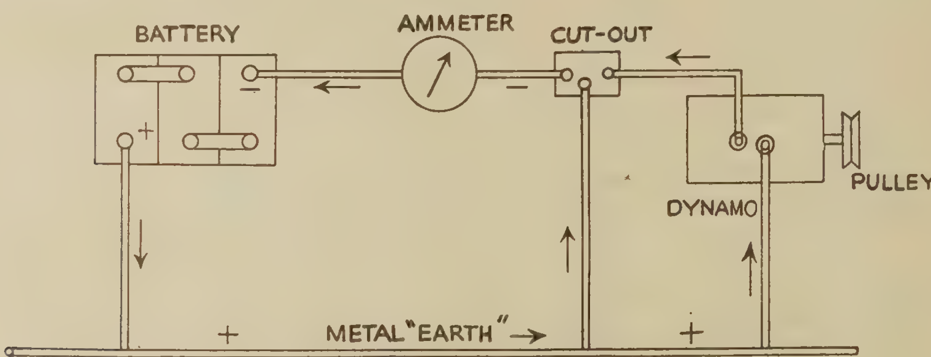


Fig. 5.—The Battery-charging Circuit.

Fig. 5 shows the simplest kind of automobile charging circuit, consisting of the battery, ammeter, automatic cut-out, and the dynamo; the latter is here assumed to be of the constant-voltage output type, over the usual range of engine speeds; its regulator is not shown in the diagram. In practice, when the engine is at rest the dynamo will not be working, since it is driven from the engine—usually by a belt-and-pulley system. If the battery were connected direct to the dynamo output terminal, current would flow from the former through the dynamo windings and the battery would in time become exhausted. After the engine has been started and is gradually speeded up, the dynamo output voltage increases

progressively until at a certain dynamo speed, termed the *cutting-in-speed*, it becomes equal to the normal battery voltage. Until this voltage is attained by the dynamo, it is necessary to provide some automatic method of disconnecting the battery from the dynamo, and one which will also connect it again once the dynamo voltage is about the same as the normal battery voltage. This connection and disconnection of the dynamo and battery cables is effected by an electrical device known as the *cut-out*, which is indicated in Fig. 5. This unit is explained more fully later, in Chapter VII. After the dynamo has attained its cutting-in speed and for all higher engine-operating speeds, the output voltage of the dynamo is maintained more or less constant at about the normal or rated battery-voltage value. It will be observed, from Fig. 5, that the battery, cut-out, and dynamo have terminals that are connected to the common earth conductor, which in the case of motor vehicles is the chassis frame and engine metal; the latter are known as the *Earth Return* circuit.

(3) **The Starting-motor Circuit.**—The starting of a car or heavier vehicle engine requires a certain physical effort at the starting handle, and apart from the inconvenience under varying weather conditions to the driver in having to descend from his seat and go to the starting handle, it is not possible for many drivers to exert the required effort to start the vehicle. Automatic means are therefore provided for starting the engine from the cold or after it has warmed up. In the case of certain heavy oil-engine vehicles, compressed air or explosive cartridges are employed for starting purposes, but in all motor-cars and the majority of commercial vehicles an electric motor is provided for starting the engine.

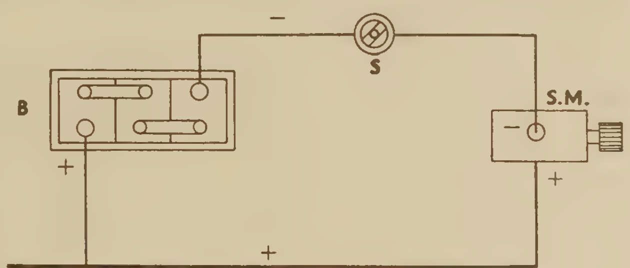


Fig. 6.—Starting-motor Circuit.

The starting motor is of sufficient power to rotate the engine at a speed of about 60 to 80 r.p.m. at freezing-point, e.g. 0° C. or 32° F. In the case of oil engines a higher speed, namely about 100 to 150 r.p.m., is generally necessary.

The starting motor used belongs to the type known as the four-pole series motor, capable of giving a high torque or turning effort at low speeds, and it is connected through a special switch to the battery in the manner indicated in Fig. 6. Upon actuating the switch S, current flows from the battery B through the motor S.M. to the common conductor, or earth, and back to the battery, thus completing the circuit. As the motor runs at a much higher speed than the required engine-starting speed, it is necessary to provide a reduction gear between the motor and engine. A

common method is to provide a small pinion or spur-gear wheel on the motor armature shaft, and to arrange for this to engage with the teeth of a large annular or ring gear shrunk on to the outside of the engine flywheel. The usual gear ratios employed range from about 10 : 1 up to 15 : 1.

It will be evident that, since the motor pinion is engaged with the flywheel gear ring only for starting the engine, means must be provided for disengaging it when the engine has commenced to operate under its own power. Automatic devices for connecting the pinion for starting and disconnecting it afterwards are fitted to all modern motor vehicles. A popular method employed on motor-cars is that in which the pinion gear

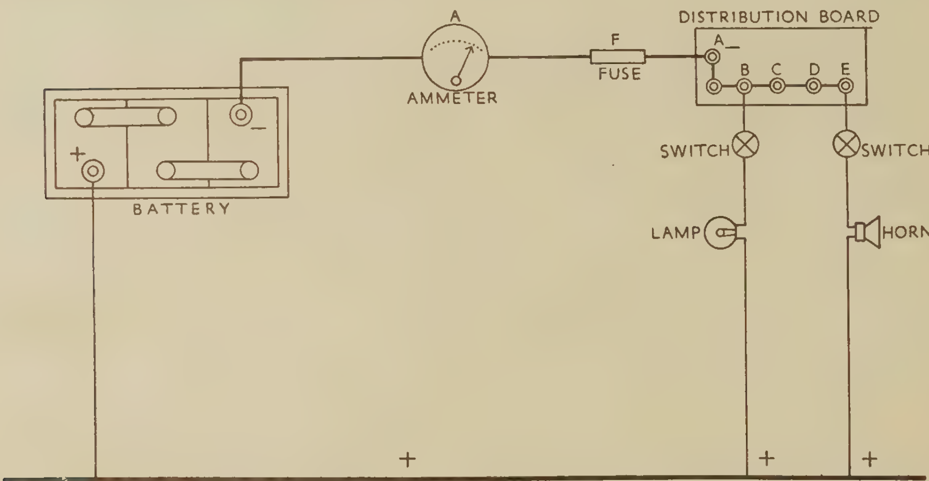


Fig. 7.—The Lighting and Accessories Circuits.

is caused to slide along the armature-shaft extension when the starter switch is operated and to slide back again after starting has been effected. It may also be mentioned that since a relatively large current is required for the starting motor during the preliminary starting operation, thick electric cables must be used for the starting-motor circuit connections.

(4) **The Lighting and Accessories Supply Circuits.**—Although the expression " circuit " is here used, in practice there is a number of separate circuits for the lamps, trafficators, electric horn, windscreen wiper, etc., but each circuit follows the same general principle of a " live " battery connection, its operating switch, the electrical component itself, and the earth connection. In addition, there is one ammeter serving all circuits except the starting-motor one. The ammeter is on the battery side of the various switches, and it shows the total value of the current.

For present purposes of explanation, it is necessary only to show typical accessories and lamp circuits, as in Fig. 7. The essentials of each auxiliary circuit are a " live " connection to a battery terminal, switch, electrical component, and an earth connection. The arrangement shown is to con-

nect the " live " side of the battery to the ammeter, and thence to take a cable through a main fuse element to a distribution unit having a number of terminals, A, B, C, D, E, etc., all wired to the battery-connected terminal A. Then, since there is a voltage equal to that of the battery between each of these live terminals and the earth conductor, all of the lamps and accessories will be supplied with this constant voltage across their terminals. This method of connecting the auxiliary electrical components is known as the parallel or shunt one. The actual arrangement of the circuits in modern vehicles differs from the more simple one shown in Fig. 7, as the lamps have their own common multi-position or selective switch and distribution terminals, whilst certain other components may draw their current supply from other parts of the " live " circuit, for reasons of convenience and economy of cable, etc. This subject is dealt with more fully later.

CHAPTER 2

USEFUL ELECTRICAL INFORMATION

The motor or electrical mechanic having to deal with automobile electrical systems must be thoroughly conversant with the elementary principles used, and also the electrical terms employed in this branch of motor engineering. Whilst the electrical specialist is familiar with the subject of electricity and magnetism, and books on this are available for reference purposes, many of our readers may not wish to delve too deeply into these and allied branches of electricity, but nevertheless are desirous of obtaining a sound electrical knowledge, sufficient for the purposes of their work.

The following information has been carefully selected for the benefit of the latter class of motor mechanic, but this should be supplemented by reference to a good elementary textbook on electricity and magnetism.

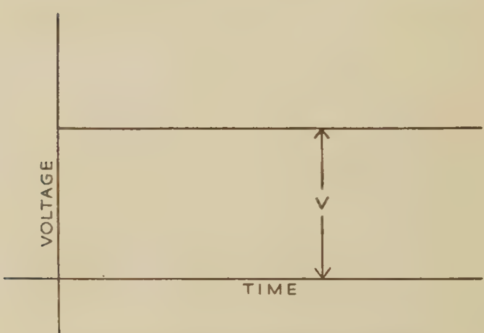


Fig. 8.—Direct Current (Constant Voltage).

Electrical Terms and Definitions

Current.—Two types of electric current are employed, namely *Direct* and *Alternating*.

Direct Current is the term used to denote a current which flows continuously in the same direction (Fig. 8). All automobile circuits employ direct current.

Alternating Current flows first in one direction and then the other. Thus the current alternates or changes in voltage from zero to a positive maximum value, then diminishes to zero and changes to a negative maximum value, afterwards diminishing to zero, thus completing the cycle (Fig. 9).

Alternating current is used for the National Grid System, for power and lighting systems. The standard supply is 230 volts, and alternating from plus 230 volts to minus 230 volts at the rate of 50 alternations or cycles per second.

The unit of direct-current measurement is the *Ampere*, and the Standard

or *International Ampere* is defined as the constant electric current which when passed through a solution of nitrate of silver in water deposits silver at the rate of ·001118 gramme per second.

In alternating-current practice the current is always changing in value, so that instead of employing the maximum voltage in calculations it is necessary to use some intermediate value, designated *virtual amperes*.[1] As we are not much concerned with alternating current in automobile electricity low-voltage circuits, it is unnecessary to deal with this branch here.

Resistance.—When electrical pressure—expressed under various names, such as *potential difference* (P.D.), *voltage*, *electromotive force* (E.M.F.), or *tension*—is applied to an electric conductor, the latter offers a certain resistance to the current flow; this resistance depending upon the cross-sectional area and length of the conductor and upon the material from which it is made. It is necessary to define this resistance in terms of a unit that can always be used in electrical calculations. For the benefit of those readers who are interested, the following is the definition of the standard or international unit of resistance, known as the *Ohm*.

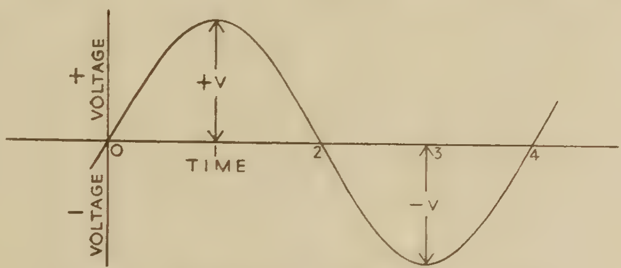


Fig. 9.—Alternating Current (Voltage Variation).

The ohm is the resistance offered to a constant (direct) electric current by a column of mercury, weighing 14·4521 grammes and of length 106·3 centimetres, the column being of constant cross-sectional area and the temperature of the mercury 0° C.

It should be mentioned that the resistance of an electrical conductor, such as a cable, does not depend upon the current or voltage applied, but is a constant for the particular dimensions and material of the conductor. The resistance of any particular conductor, however, changes with its temperature, the resistance increasing as the temperature rises.

Materials such as copper and aluminium, which are known as good electrical conductors, have relatively low resistances, whilst poor conductors or high-resistance materials, such as nickel-chrome, Eureka, and Manganin wires used for heating elements, have high resistances. Thus the resistance of 16 S.W.G. (·064 in.) hard-drawn copper wire is about 7·5 ohms per 1,000 yards at 60° F., whereas that of Eureka wire of the same diameter and length is 210 ohms at 60° F.

Voltage.—When the electrical pressure applied to a conductor of 1 ohm resistance causes a current of 1 ampere to flow, the value of this pressure or " potential difference " is defined as 1 volt. The expression " voltage drop " or " potential difference " is used to denote the voltage

[1] The square root of the mean of the instantaneous values squared.

that is required to overcome the resistance of the circuit. This voltage is often referred to in connection with the testing of dynamo armature coils.

Fractions and Multiples of Electrical Units.—In electrical measurements and specifications it often occurs that large multiples of units, such as amperes or volts, are employed. In other instances, as in the case of fine measurements, small fractions of these units are frequently referred to. In such cases it is convenient to use certain prefixes to avoid the use of large numbers or small fractions. In this connection the following are the more commonly used prefixes:

ELECTRICAL PREFIXES AND APPLICATIONS

Prefix	*Meaning*	*Examples of Use*
Kilo	One thousand	Kilowatt = 1,000 watts. Kilovolt = 1,000 volts.
Milli-	One thousandth	Millivolt = $\frac{1}{1000}$ volt. Milliampere = $\frac{1}{1000}$ ampere.
Meg(a)	One million	Megohm = 1,000,000 ohms.
Micro	One millionth	Microvolt = $\frac{1}{1000000}$ volt. Microfarad = $\frac{1}{1000000}$ farad.

Ohm's Law.—One of the most widely employed and at the same time the simplest of electrical relations is that expressing the relationship between current, voltage, and resistance in a conductor. Thus, if a potential difference between the two ends of a conductor of resistance R (ohms) is denoted by V (volts) and the current that is caused to flow through this conductor is A (amperes),[1] then Ohm's law states that:

$$C = \frac{V}{R}, \text{ or } R = \frac{V}{C}, \text{ or } V = CR.$$

Example.—Find the value of the current flowing through a copper wire of 16 S.W.G. and length 1,000 yards when a voltage of 22·5 is applied between the two ends. The resistance of this length of wire is 7·5 ohms.

In this example V = 22·5 volts and R = 7·5 ohms.

$$\text{Therefore the current } C = \frac{V}{R} = \frac{22\cdot5}{7\cdot5} = 3 \text{ amperes.}$$

It will be seen from this example that if the resistance of a conductor is increased less current will flow, and if decreased more current flows. In *battery-charging circuits* the correct charging current is obtained by altering the resistance of the circuit either with the aid of electric lamps of known resistance or by means of a variable-resistance device, known as a *rheostat.* The actual value of the resistance required can be worked out for each type and number of battery.

Joule's Law.—When a current C due to an impressed voltage V flows through an electrical conductor of resistance R for a period of time

[1] In all future references, unless otherwise stated, it will be assumed that R, V, and C are always xpressed in ohms, volts, and amperes respectively.

denoted by t seconds, the electrical energy expended in the circuit is converted into heat according to the following relationship:

$$\text{Heat generated} = C^2Rt \text{ Joules.}$$

Here the electrical-energy unit is termed the Joule, the value of which is given later in these considerations.

In passing, it may be noted that to obtain the greatest heating effect for a given current consumption and time, the resistance R should be as large as possible. Thus for a given length of wire the high-resistance wires made of nickel-chrome, Eureka, Manganin, etc., referred to previously, would be employed in electrical heating devices.

Electrical Power Units.—The power unit employed in electrical work is that known as the *Watt*, and it is expressed by the product of current and voltage.

$$\text{Thus one watt} = 1 \text{ ampere} \times 1 \text{ volt.}$$

Example.—Find the power absorbed when a current of 4 amperes flows through a 12-volt motor-car headlamp bulb.

In this case $C = 4$ amperes and $E = 12$ volts, so that

$$\text{Watts} = 4 \times 12 = 48.$$

Similarly, it can be shown that a 12-volt side-lamp bulb of the usual 6-watt type will require a current of ·5 ampere.

Some other usual power and energy relationships are as follows:

$$1 \text{ Joule} = 1 \text{ watt per second,}$$
$$\text{or Joules} = \text{amperes} \times \text{volts} \times \text{seconds.}$$

The *Kilowatt-hour* = 1,000 watts per hour. This unit, denoted briefly as kW, is that used for electricity consumption charges. Thus a charge of 2*d. per unit* means that the electrical consumption of 1,000 watts per hour would cost 2*d.*

Horse-power.—There is a useful relationship between mechanical horse-power and electrical energy as expressed in kilowatt-hours.

Thus 1 kilowatt-hour = 1·34 h.p. hours.

$$\text{Or } 1 \text{ h.p.} = 746 \text{ watts (or 1 electrical horse-power).}$$

It should be noted that a mechanical horse-power (h.p.) is the rate of doing mechanical work of 550 ft.-lb. per second or 33,000 ft.-lb. per minute.

Example 1.—Find the current consumption of a 12-volt type starting motor of $\frac{1}{3}$-h.p. output, neglecting minor losses.

$$\tfrac{1}{3} \text{ h.p.} = \frac{746}{3} = 248{\cdot}66 \text{ watts.}$$

Then, since watts = amperes × volts,

$$248{\cdot}6 = \text{amperes} \times 12.$$

From which the current $= \dfrac{248{\cdot}66}{12} = 20{\cdot}72$ amperes.

Example 2.—What horse-power would a dynamo be delivering, theoretically, when charging a car battery of 12 volts with a current of 12 amperes? Here the watts delivered $= 12 \times 12 = 144$.

Therefore the h.p. output will be $\frac{144}{746} = \cdot 193$ or approximately $\frac{1}{5}$ h.p.

The actual h.p. absorbed by the dynamo would, of course, be appreciably greater, because of the internal electrical (or heat) losses. Thus it would require about $\frac{1}{4}$ h.p. to drive the dynamo under these conditions.

Electrical Circuits

Series Connections.—When two conductors A and B of resistances R_A and R_B are connected end-to-end, as shown in Fig. 10, they are said to be connected in series.

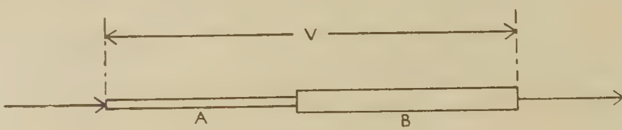


Fig. 10.

Then the total resistance of the conductors $= R_A + R_B$.

If a voltage of V be applied across the ends of the conductors, the value of the current C flowing through them will be:

$$C = \frac{V}{R_A + R_B}.$$

When two conductors A and B are connected as shown in Fig. 11, they are said to be connected in *parallel* or *shunt*. If their resistances be denoted

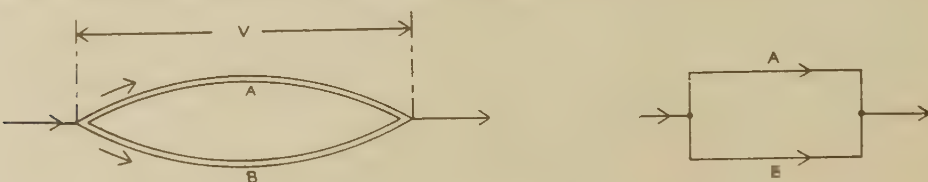


Fig. 11.—Two Conductors in Parallel.

by R_A and R_B respectively and the currents in the wires by C_A and C_B, then for an applied voltage V across the junctions the following relations hold:

$$C_A = \frac{V}{R_A}, \qquad C_B = \frac{V}{R_B}.$$

Also the main current $C = C_A + C_B$.

The total resistance R of the circuit is obtained from the formula:

$$\frac{1}{R} = \frac{1}{R_A} + \frac{1}{R_B}, \text{ from which } R = \frac{R_A \times R_B}{R_A + R_B}.$$

If three conductors A, B, and C are connected in parallel (Fig. 12). then, using the same notation:

$$\frac{1}{R} = \frac{1}{R_A} + \frac{1}{R_B} + \frac{1}{R_C}, \text{ or } R = \frac{R_A \times R_B \times R_C}{R_A \cdot R_B + R_A \cdot R_C + R_B \cdot R_C}.$$

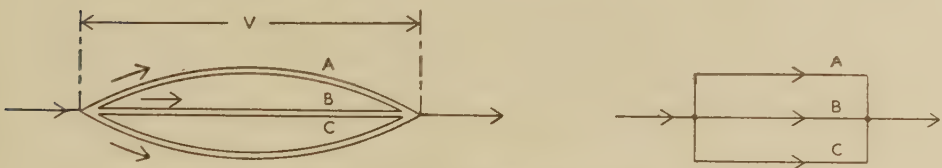


Fig. 12.—Three Conductors in Parallel.

The currents in A, B, and C are as follows:

$$C_A = \frac{V}{R_A}, \quad C_B = \frac{V}{R_B}, \quad C_C = \frac{V}{R_C}.$$

Also total input current $C = C_A + C_B + C_C$.

Parallel Circuit Notes.—Referring to the right-hand diagrams in Figs. 11 and 12, these indicate the conventional way in which parallel wiring is shown on many electrical diagrams. Thus, in the case of domestic lighting where all of the lamps are wired in parallel, so that each lamp when switched on by its own switch S has the full mains voltage (230 volts) across its terminals, the basic wiring diagram will be as shown in Fig. 13. The wall plugs have terminals giving the mains voltage across them, so that any electrical apparatus (such as R in Fig. 13) is

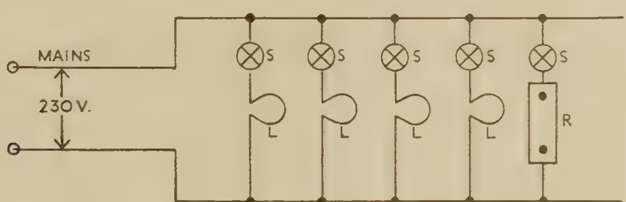


Fig. 13.—Lamps wired in Parallel.

automatically connected in parallel with the mains when it is plugged in. It may be mentioned that these considerations apply equally to *direct* and *alternating current*, but the formulæ given previously *apply only to direct current*, e.g. the automobile electrical system.

Use is often made of the properties of parallel circuits *in battery charging*, where it is sometimes necessary to provide charging currents of different values to suit different types of batteries requiring to be charged at the same time. Thus, by inserting into each of the separate parallel circuits suitable resistances, the required current can be obtained. Further, the

actual value can be deduced from the formulæ given previously for parallel circuits, but these are expressed more conveniently as follows (Fig. 14):

Current in circuit A $= \dfrac{V}{B_A + R_A}$, where B_A = resistance of battery and V = voltage across circuit.

Current in circuit B $= \dfrac{V}{B_B + R_B}$.

Current in circuit C $= \dfrac{V}{B_C + R_C}$.

In practice it would be advisable to insert an ammeter in series with each of the separate circuits as at A, B, and C, to ensure that the correct charging current is being used.

It would also be necessary to have an ammeter, such as that shown at M in Fig. 14, in the main supply lead. Here it may be added that it does not matter where the ammeter is inserted in each circuit, since the current value is constant all through each individual circuit. As the subject of battery charging from mains electricity supply, suitably converted to direct current if of the standard alternating current, is dealt with later in this volume, further detailed reference is unnecessary here.

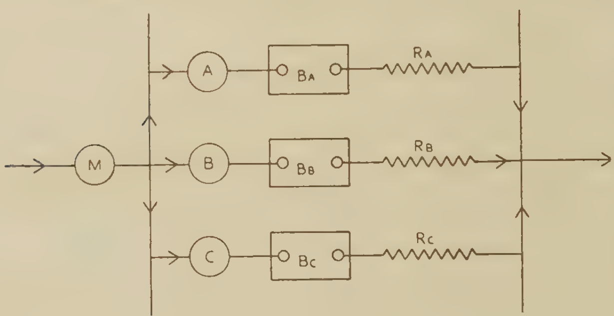


Fig. 14.—Batteries in Parallel.

Two Important Circuit Laws.—Before proceeding, however, it may be useful to mention two important properties of electrical circuits that were first discovered by Kirchhoff and are known as *Kirchhoff's Laws.* A knowledge of these laws is very useful to the automobile electrical mechanic.

The *first law* states that in a network of conductors, e.g. that shown previously in Fig. 12, the sum of the currents at any junction is zero. In this connection currents flowing *towards* the junction may be regarded as positive, whilst those flowing *away* are negative. Thus, in the example shown in Fig. 12 it has already been shown that $C = C_A + C_B + C_C$, so that, as stated by Kirchhoff's first law, $C - C_A - C_B - C_C = 0$.

The *second law* states that in travelling round any portion forming a closed circuit, the algebraic sum of the electromotive forces (voltage differences) is equal to the algebraic sum of the products of current and resistance.

Referring again to Fig. 12 and using the same notation as before, this law states that in each portion of the network, such as A, B, or C, the volt-

age across the ends is equal to the product of the current in each and its resistance.

Thus, for the branch A the voltage $V = C_A \times R_A$;
for B ,, ,, $V = C_B \times R_B$;
and for C ,, ,, $V = C_C \times R_C$.

In this example, which is a simple illustration, there is the same voltage across each circuit member A, B, and C.

It may be added, however, that the two laws mentioned apply equally well to complex networks, including those having several sources of electrical supply, e.g. circuits having more than one battery in their different branches.

Properties of Electrical Condensers

The automobile engineer should have some knowledge of condensers, since these are used in the ignition apparatus and also as suppressors in connection with radio installations. The condenser may be regarded as a device for storing up static electricity so that when required this static charge can be utilised for any required purpose. A typical condenser consists of two parallel metal plates separated by an insulating material (Fig. 15). Thus tinfoil is often used for automobile condensers with bakelite or mica as the insulator. When the outer metal plates are connected to the positive and negative terminals of a source of electricity, the condenser becomes charged electrically. If, then, the charging source is disconnected and the plates are connected with a metal conductor, the condenser will become discharged.

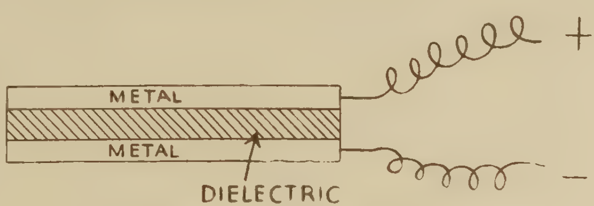


Fig. 15—Principle of the Electric Condenser.

The amount of electricity a condenser will store depends chiefly upon the size of the plates, and in the case of multi-plate condensers on the number of plates used. It depends also upon the insulating or dielectric material and the distance apart of the plates. In electrical parlance, the ability to store electricity depends upon the *capacity* of the condenser. The formula for capacity is as follows:

$$\text{Capacity of condenser} = \frac{k\,S\,A}{d}$$

where S = specific inductive capacity of the "insulator"; A = total area of the plates; d = distance between the plates; and k is a constant. Typical values are: when A is in square inches and d in inches the value of k is about $\frac{1}{4500000}$, and the results are given in the *microfarad* units of capacity. Values of S are: 5 to 10 for bakelite, 4 to 8 for laminated bakelite, 5 to 8 for mica, 5 to 10 for glass, and 2 to 2·3 for paraffin wax.

The type of condenser used for the contact breakers of ignition circuits is the multi-plate one, having several plates of very thin tinfoil separated by mica, bakelite, or waxed paper (Fig. 16). Each set of plates is insulated by the dielectric from the other set, and the ends of each set are all connected together and taken to the lead-terminal eyelets. Condensers may be of the flat or cylindical pattern for automobile purposes, and both types have been widely used. Coil-ignition condensers use rice or tissue-paper between tinfoil plates, and are vacuum dried and wax impregnated, being finally sealed in a cylindrical metal case. The usual capacity of automobile ignition condensers is from ·1 to ·3 microfarad, and it should be able to withstand 1,000 volts across its terminals without breakdown.

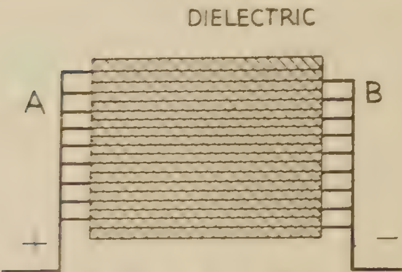


Fig. 16.—Principle of the Multi-plate Condenser. The two sets of plates connected to the leads A and B are entirely insulated from each other.

If the positive and negative terminals of a condenser are connected to a wireless type of dry battery (60 to 100 volts) or across a D.C. mains supply, the plates become charged with static electricity. If now two insulated pieces of wire are connected, with one end to each terminal of the condenser and the other ends are gradually brought together, a spark will pass across the air gap just before they meet. This is one method of testing whether a condenser is in good condition, but to safeguard against a dead short between the condenser plates a fuse should first be inserted in the condenser-charging circuit; sometimes a lamp is placed in series with the condenser, and if it lights up this is an indication of condenser-plate shorting.

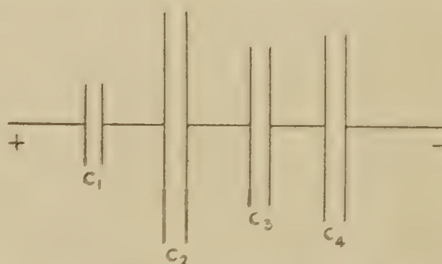


Fig. 17.—Condensers in Series.

When two or more *condensers are connected in series* (Fig. 17) the combined capacity is equal to the sum of the reciprocals of the individual capacities. Thus, if C_1, C_2, C_3, etc., be the capacities of the individual condensers, then the combined capacity C is given by:

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \text{etc.}$$

As an example, if two condensers of equal capacity be connected in series, then the combined capacity will be one-half that of a single condenser; if three similar ones are connected in series, the combined capacity will be one-third that of a single condenser.

If, on the other hand, a number of different *condensers are connected in parallel* (Fig. 18), then the combined capacity will be equal to the sum of the individual capacities. Thus, using the previous notation, the combined capacity $C = C_1 + C_2 + C_3 + \ldots$ etc.

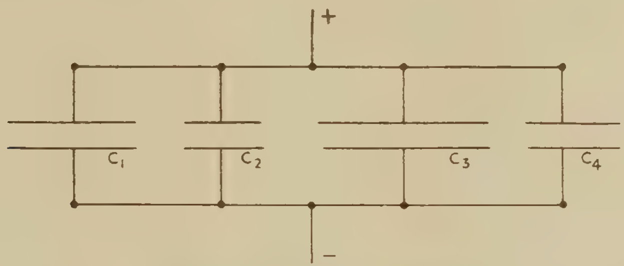


Fig. 18.—Condensers in Parallel.

As an example, if two similar capacity condensers are connected in parallel the combined capacity will be twice that of each condenser; if three are connected in parallel, the combined capacity will be three times that of the individual one.

CHAPTER 3

THE IGNITION SYSTEM

A BRIEF survey of the principles of ignition will no doubt afford a useful introduction to the practical side which follows. In the first place the object of the ignition device or system fitted to every petrol-type engine is to provide an electric spark of great intensity, or voltage, to ignite the mixture of air and petrol vapour compressed within the particular cylinder of the engine which is at the end of the " compression stroke." It has been found that a sufficiently intense spark, to break through such a highly compressed mixture satisfactorily, requires a voltage of at least 3,000, across a pair of sparking points, or electrodes, situated about one-half a millimetre (i.e. about $\frac{1}{50}$ in.) apart. If such a spark were arranged to discharge in ordinary air, it would be found that the electrodes could be separated to at least 10 millimetres (i.e. about $\frac{3}{4}$ in.) and yet still spark.

More generally, with the usual sparking-plug gaps of ·015 to ·022 in. and for modern high-compression engines, a sparking voltage at the plug electrodes of 4,000 to 6,000 is employed, but higher values up to 8,000 volts are occasionally used.

Ignition-spark Considerations

The voltage required to bridge the plug points or gap in the cylinder has been found to depend upon the width of the gap, being greater as this width is increased. This is the chief reason why sparking-plug points require occasional checking for correct gap distance, for the electrodes " wear " away when in constant use. The voltage required for efficient sparking also depends upon the compression pressure; a higher value is required for high compressions than for low ones.

One result of this compression effect is that whilst an engine may " fire " when starting and at small throttle openings—corresponding to reduced compression pressures in the cylinder—sometimes *it will not " fire " when the throttle is opened wider*; for then the compression pressure is increased and there is not sufficient voltage to produce a spark at the plug points. In such cases the cause may be too wide a plug gap or faulty ignition unit, i.e. magneto or coil-ignition.

Another important factor is the temperature of the plug's electrodes, for tests have shown that as the temperature increases the voltage re-

quired to produce the ignition spark falls. This is a beneficial effect, since as the throttle is opened the points become hotter and less voltage is needed for the spark. It will be understood from these considerations that the detrimental effect of increasing compression on the plug voltage is more or less counteracted by the beneficial influence of increasing plug temperature. Again, *when the engine is cold* the voltage needed for the ignition spark will be appreciably greater for the same compression than when the engine is hot.

There are other minor factors affecting the ignition voltage, such as mixture strength, design of the electrodes, condition of electrodes, and ignition timing. Incidentally, a weak mixture requires a much higher sparking voltage than a rich one for the same compression pressure.

Two Alternative Ignition Systems

There are two important types of ignition apparatus in general use to-day, namely the *Batterv and Coil* (usually designated *Coil-ignition*) system and the *Magneto*. The former takes advantage of the fact that since a starting and lighting battery must be carried on the car, it can also be arranged to furnish the small amount of electrical energy necessary for the ignition. The latter device is quite a separate unit, being in essence an engine-driven dynamo-converter.

The coil-ignition system possesses a marked advantage over the ordinary magneto type in that it is possible to obtain a really satisfactory spark at extremely low engine speeds—in fact, at the lowest possible speed of running. Further, unlike the magneto, which gives a spark of increasing intensity at the higher speeds, and therefore one which tends to burn away the sparking-plug points, the coil-ignition system gives a practically uniform high-intensity spark *at all speeds*; it is for this reason that high-speed and racing cars are almost invariably provided with battery ignition, although modern magnetos are used in some instances. The camshaft magneto, however, has more recently come to the fore, since it combines the advantages of both systems.

The advantage of being able to obtain a good spark at very low speeds relieves the electric starting motor of much of its work. In the case of many magneto-ignition cars, starting from the cold was found to put a big strain upon the battery, for the starting current drawn therefrom is a very heavy one—usually from 100 to 400 amperes.

The magneto is more expensive than the equivalent coil-ignition unit, and this is another reason why it has been superseded on all modern motor-cars and the majority of later commercial vehicles, but more particularly mass-produced ones. The magneto is extremely reliable and is independent of any battery condition of charge. It has a big advantage in the latter respect over the coil system, since cases have frequently occurred in which the batteries of cars left unused over a period of many weeks have been found to be " run-down " so much that they have failed to produce

enough electricity for ignition starting purposes. Had a magneto been fitted and the engine sufficiently free to crank by hand, the engine could have been started.

In regard to reliability, the modern coil system, apart from the battery, is just as reliable as the magneto; a fact that is recognised by the manufacturers of the Rolls-Royce cars since, formerly, both magneto and coil ignition units were fitted, but more recently only the coil system is employed.

Another reason for the falling off in the use of magnetos for commercial vehicles has, of course, been the change over from petrol to oil engines; the latter type requiring no high-tension ignition system but, in a few instances, a low-voltage heater system for cold starting.

The Coil-ignition System

It is interesting to note that this system was about the first—if we except the hot-tube or flame method of ignition in the earliest internal-combustion engines—to be successfully employed for automobile engines. The actual system most widely used in early days of the automobile followed the low-tension plug one and was an adaptation of the well-known Rumkorff or induction coil method, which produced a shower of high-voltage sparks by means of a vibrating or " trembler " coil. The trembler coil was simply a double coil wound with a few turns of relatively thick wire, over which a large number of turns of fine wire were then wound. The former coil was termed the *Primary* and the latter the *Secondary*. The effect of interrupting the flow of current in the primary circuit is to cause a big increase in the voltage of the temporary current flowing in the secondary. The voltage in the latter circuit is equal approximately to that of the primary multiplied by the ratio of the number of turns in the secondary to the number in the primary; hence the necessity for the very large number of turns in the secondary for a high-voltage effect.

In the modern high-tension coil unit there is a somewhat similar arrangement of primary and secondary coils constituting an electrical transformer. In addition there is a contact breaker driven at engine speed, or one-half engine speed, in order to give the interruptions in the current flowing in the primary, in synchronism with the engine speed. The high-tension spark thus created at regular intervals must be directed to its correct sparking plug. For this purpose a distributing device, consisting, previously, of a revolving carbon brush which rubbed across insulated metal segments connected to the respective cables leading to the plugs, was embodied in the unit; this is termed the *distributor*. Further, in order to prevent excessive sparking, and therefore burning away of the primary-circuit contacts, an electrical condenser, consisting of pieces of tinfoil separated by mica plates, is fitted in parallel with the contact breaker. Thus we have the following components in a modern H.T. coil-ignition unit: *Primary Winding*, *Secondary Winding*, *Contact Breaker*, *Distributor*, and *Condenser*.

In connection with the transformer, it should be added that the primary and secondary windings have a common *Central Core* made up of a large number of soft iron rods.

The secondary coil consists of several thousands of turns of very fine wire.

One end of the secondary is usually connected to the centre terminal of the coil, while the other end is connected to one end of the primary winding in some coils, whilst in others it is connected to the " earth " or frame of the car.

The Coil-ignition Circuit

Fig. 19 is a diagrammatic sketch of the wiring arrangement of the ordinary battery-ignition coil.

Two distinct circuits are shown in this diagram, namely: (1) the low-tension one comprising the battery, switch, contact-breaker primary coil, and earth return, and (2) the secondary or high-tension one, comprising the secondary coil, sparking plug, and earth return. The engine-driven cam (shown in Fig. 19) closes the primary circuit through the medium of the contact breaker once for every two revolutions of the engine crankshaft—since there is one firing stroke every two revolutions.

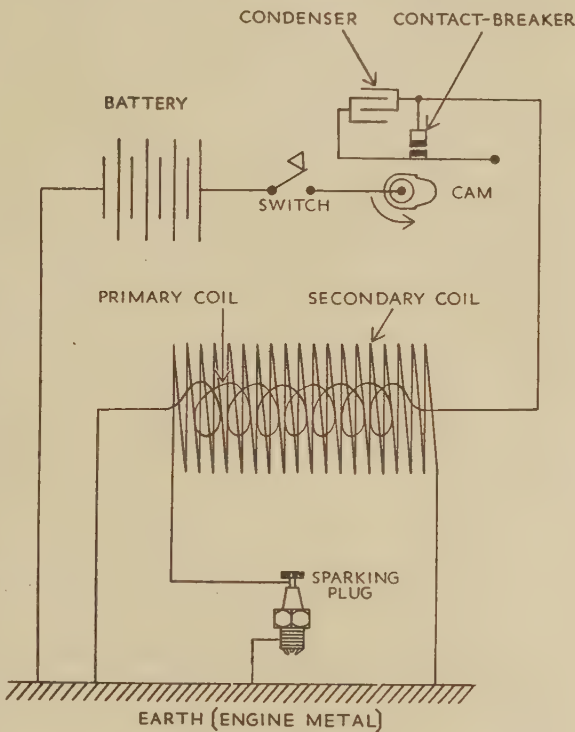


Fig. 19.—The Coil-ignition System.

It will be observed that one end of the primary and one of the secondary are both "earthed" to the engine frame, as is the negative side of the battery. The engine frame thus forms a common return path.

Fig. 20 shows the battery-ignition arrangement in more detail in the case of the Delco-Remy four-cylinder battery-ignition unit. It is of interest to follow out this diagram.

Commencing with the positive terminal A of the battery, a low-tension current from the battery flows from this through the ignition switch B to one end of the resistance unit C to the primary winding D of the coil. The far end of the primary winding is carried on to a terminal E on top of the coil, which is connected to the insulated circuit or contact breaker F.

When the contact-breaker points are closed, current passes to the points F and G, thence on through the contact-breaker arm to the main metal casting of the distributor, which is in electrical contact with the engine and frame of the car. The circuit is then completed through these parts to the negative terminal of the accumulator H.

As the distributor cam rotates and separates the points F and G, the current through the primary D is suddenly interrupted, setting up a very high voltage in the secondary winding J. One end of this winding is connected to the rotating segment assembly in the distributor by means of a rubbing contact taken through a small carbon brush and a steel spring. As this segment assembly rotates, it carries with it a small metal segment which passes the current to metal inserts (the number of which depends upon the number of cylinders) fixed at equal intervals in the insulated distributor cap. This metal segment is insulated from the camshaft which drives it, and is so arranged that whenever the cam opens the contact-breaker points it is opposite one of these metal inserts.

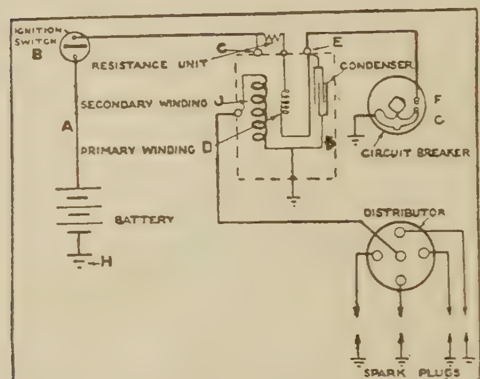


Fig. 20.—Illustrating the Principle of a Four-cylinder Engine Coil-ignition System.

The high voltage set up in the secondary winding by the sudden interruption in the primary causes the current to flow to the segment and jump across the small air gap between it and the insert, and thence pass to one of the sparking plugs. The return circuit is completed through the body of the engine to the base of the coil, to which base the other end of the secondary winding is connected.

The condenser previously described is connected across the contact breaker, one end being connected to the contact-breaker point F, and the other to the point G through the body of the engine or chassis parts.

Speed of Distributor Arm

In four-cycle multi-cylinder engines it is necessary to provide one spark per cylinder at intervals of two crankshaft revolutions. It will be understood that the rotating arm of the distributor unit causes a spark to occur at each plug every time it comes opposite the contact segment that is electrically connected to that plug. It follows from this that the distributor arm must revolve at one-half the engine speed. Since it is also arranged that the rotating cam which operates the contact breaker runs at half engine speed, both the cam and distributor arm are driven from the same half-speed shaft; the latter shaft therefore runs at the valve cam-

shaft speed, and can be driven off the latter through equal gearing. In two-stroke engines the distributor and camshaft run at engine speed.

The Contact-breaker Cam

The usual arrangement for the cam that operates the contact breaker is to have one lobe on the cam for each cylinder of a multi-cylinder engine, and to run the cam at one-half engine speed. Thus a single-cylinder four-cycle engine would have one lobe, a four-cylinder engine four lobes, and a six-cylinder engine six lobes. There is, however, an important factor that limits the number of lobes in high-speed multi-cylinder engines, for tests have shown that the modern high-tension coil and contact-breaker systems require a minimum period of $\frac{2}{1000}$ second for the closed period of the contacts, and this limits the maximum speed of multi-cylinder engines. Thus an eight-cylinder contact breaker could not run satisfactorily on this account at an engine speed exceeding about 5,000 r.p.m. with the ordinary coil and contact breaker, so that it is necessary to use two contact breakers and a cam having four lobes. The six-cylinder engine's limited sparking speed due to the above factor and with the standard ignition units is about 6,500 r.p.m. If higher engine speeds are required, a special design of high-tension coil and contact breaker must be used. There is another factor that limits the maximum operating speed of ordinary production-type contact breakers, namely the weight or inertia effect at high speeds, which results in the throwing out of the contact-breaker arm at engine speeds above 5,000 r.p.m. or 2,500 r.p.m. for cam. In high-speed contact breakers the arm is made as light as possible by suitable design and sometimes the use of a light alloy. Further, to oppose the throwing or flinging out tendency, the contact-arm return spring is made stronger; too much spring pressure cannot, however, be used, as the contact points then wear more rapidly. With suitably designed coil-ignition equipment, engine speeds up to 10,000 r.p.m. for six-cylinder engines are attainable. It may also be mentioned that the 12-volt electrical system is better than the 6-volt one for high engine-speed ignition.

The High-tension Coil

As mentioned previously, the high-tension coil behaves as an electrical transformer in conjunction with the make-and-break system in the low-tension circuit. It consists of a cylindrical soft-iron core upon which is wound the primary winding, having relatively few turns of insulated, e.g. enamelled, copper wire of low resistance, namely ·7 to 1·5 ohms, around which are wound a very large number of insulated wires of small diameter. Usually from 15,000 to 20,000 turns of wire of about 40 to 44 S.W.G. are used. The resistance of this secondary winding is about 2,000 to 3,000 ohms.

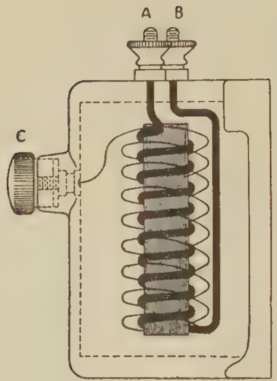


Fig. 21.—The High-tension or H.T. Coil.

A typical coil of the kind described is shown diagrammatically in Fig. 21, and for explanatory reasons the two ends of the primary winding are shown connected to the two terminals A and B and one end of the secondary winding to the terminal C. The high-tension cable from C goes to the centre of the distributor and thence—usually by a spring-loaded carbon brush—to the rotor arm of the distributor.

In regard to the low-tension terminals, that at A would be connected to *the contact-breaker insulated terminal*, whilst B, which is connected to the common junction of the primary and secondary coils, is joined to the battery terminal, namely the negative one in modern car practice. The positive terminal of the battery and the movable contact on the contact-breaker arm are both " earthed " to the engine metal (and chassis frame).

In *modern high-tension coils* the arrangement of having the primary winding inside and secondary outside (Fig. 21) is reversed, the primary coil now being outside. The secondary coil is made rather shorter in length than the primary one, and in addition to the central soft iron core an iron sleeve is arranged around the outside of the primary coil, the sleeve being slotted for cooling purposes and placed inside a thin sheet-metal casing for protection. This design of coil is more efficient than that illustrated in Fig. 21.

A view of a typical modern high-tension coil is shown in Fig. 22; the various parts and the terminals are indicated by the lettering. In regard to the terminals, of which there are three in number, the two low-tension ones, marked "S.W." and "C.B.," are

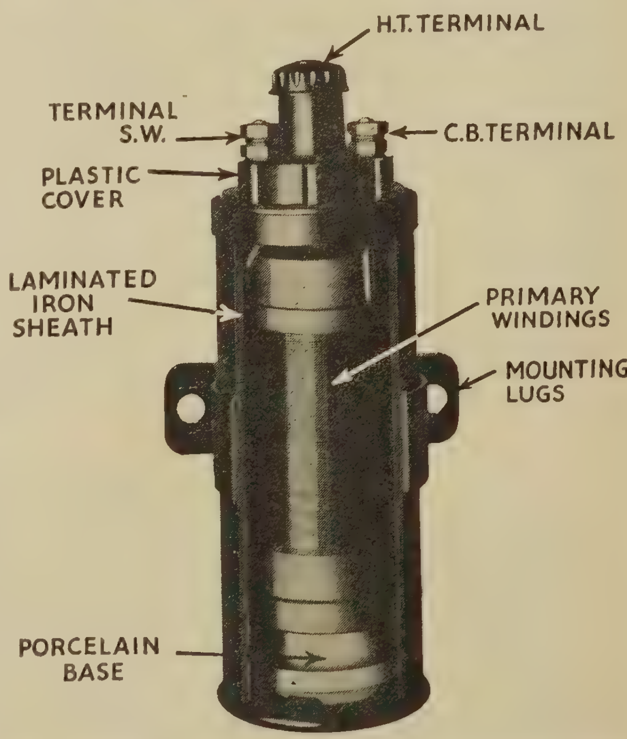


Fig. 22.—The Lucas H.T. Coil with part of Casing removed to show the construction.

connected to the ignition switch and contact-breaker external casing terminals respectively. The central insulated terminal carries the H.T. cable from the coil to the rotating arm of the distributor. As this cable transmits high-voltage current, it should be of similar type to the sparking-plug leads.

The layout of a typical four-cylinder high-tension system, namely that used on the Morris Commercial LC and PV engines, is shown in Fig. 23. Here the double-line cables are high-tension ones and the single black lines low-tension ones. The sparking-plug cable connections and their numbering show also the order of firing, since the rotor arm of the distributor directs the spark current to each of the four distributor-metal contacts or segments in the same order as the firing one, namely 1, 3, 4, 2. It will be observed that the low-tension cable from the coil terminal, marked C.B., is taken to a terminal on the moulded contact-breaker and distributor casing.

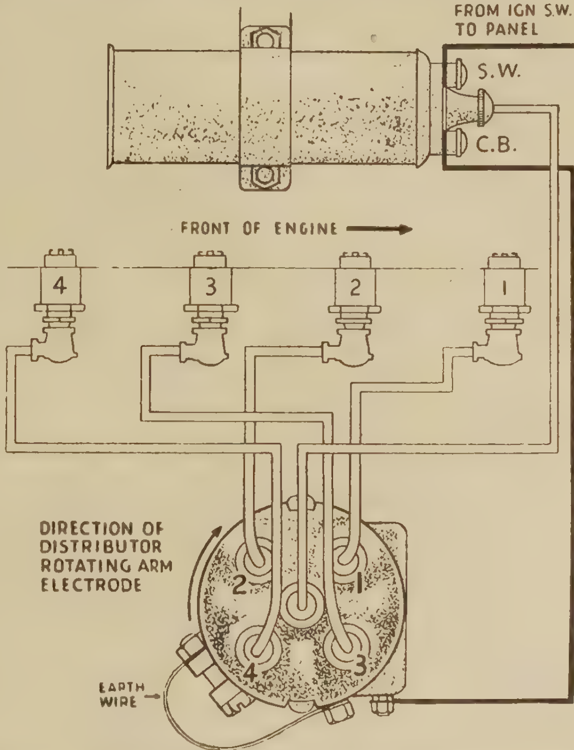


Fig. 23.—Typical H.T. Ignition System (Morris Commercial Cars).

Insulated and Earth-return Coil-ignition Systems

There are two principal methods of arranging the low-tension systems in the case of coil ignition, known, respectively, as the *Insulated* and *Earth Return*.

Fig. 24 illustrates the former system. In this case there are two insulated leads from the battery to the dynamo, and from the latter to the primary winding of the coil and contact breaker respectively. One end of the secondary-coil winding is earthed, however, to the frame of the chassis, in order to complete the circuit to the sparking-plug shells, thence across the spark gaps and back through the distributor to the other end of the secondary winding.

With the earth-return system shown in Fig. 25, the negative pole of the battery, one side of the condenser, and the moving contact-breaker

arm are earthed; the negative pole of the dynamo is also earthed. It will thus be seen that the "earth" or metal of the engine and frame take the place of the insulated lead shown in Fig. 24, so that the primary circuit

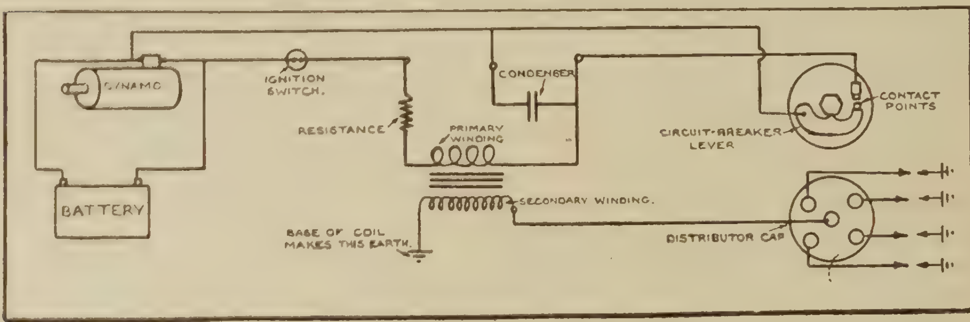


Fig. 24.—Wiring Diagram of Insulated Coil-ignition System.

is completed through the frame when the contact-breaker contacts are closed.

The advantage of the earth-return system is that only one cable is required, instead of the two used in the insulated system.

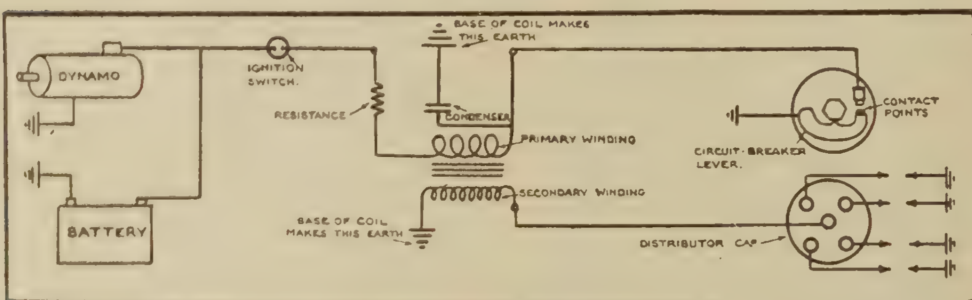


Fig. 25.—Wiring Diagram of Earthed Coil-ignition System.

It should be mentioned that, although the negative pole of the battery is shown "earthed" in Fig. 25, it is now usual to "earth" the positive pole as this method has certain advantages, referred to later. A typical positive earthed circuit is shown in Fig. 47 on page 47.

Testing Ignition Low-tension Circuit

To test the low-tension system in the event of ignition trouble not traceable to the high-tension circuit or a partly charged battery, it is first advisable to measure the *voltage available at the coil* for the battery circuit. This can be done by connecting a 0 to 20- or 30-volt voltmeter in the manner

indicated in Fig. 26. Here it will be seen the distributor low-tension cable from the contact-breaker, or C.B., terminal of the coil has been disconnected at the distributor end and the latter earthed to the engine metal. One terminal of the voltmeter is connected by means of an alligator clip at its cable end to the S.W. coil terminal, whilst the other voltmeter cable is earthed.

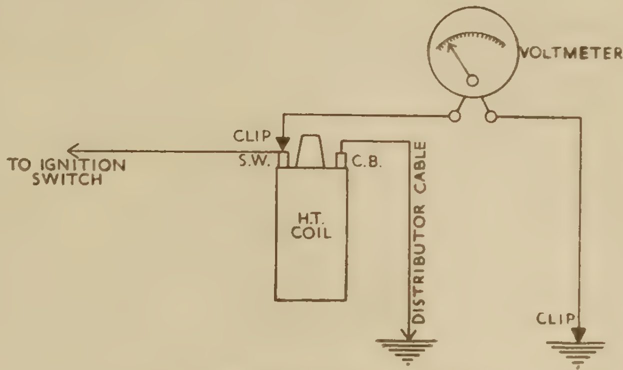


Fig. 26.—Testing the Low-tension System.

When the ignition is switched on, the voltmeter should give the full battery-voltage reading, i.e. 6 volts or 12 volts according to the type fitted. The starting motor should then be operated when the closed battery-circuit reading will be given by the voltmeter. Its value should be about 4 volts for a 6-volt battery and 8 volts for a 12-volt one.

If the voltage reading is less than these values, this is an indication of loose or dirty connections or a faulty cable in the circuit between the starter-motor switch and ammeter and the cable leading to the H.T. coil.

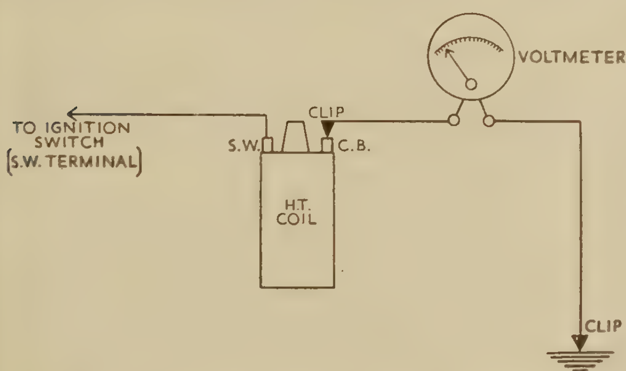


Fig. 27.—Checking Ignition-coil Primary Windings.

To check Ignition-coil Primary Windings.—Connect up the voltmeter as shown in Fig. 27. In this case one of the voltmeter leads is connected to the C.B. terminal after disconnecting the cable from this terminal to the distributor casing terminal. The other voltmeter lead is earthed. When the ignition is switched on, the voltmeter should show about the full battery voltage. If the reading is appreciably lower this will indicate a high resistance in the H.T. coil primary, and if *no reading* at all is given, it is a sure sign of a break in the primary winding or at the terminal internal connection.

To Check for Faulty Coil-distributor Cable.—This test, which will also reveal if the contact-breaker condenser is faulty, is carried out simply by connecting the voltmeter between the low-tension terminal on

the distributor casing—to which the C.B. terminal cable is normally connected—and any convenient earth point (Fig. 28). If the low-tension cable between the coil and distributor is in sound condition and the terminal connections are good, the voltmeter will show the full battery voltage when the *contact-breaker points are open* and *the ignition is switched on.* If a lower reading is given, this indicates a faulty cable, bad or loose connections, or a faulty condenser across the contact-breaker points. The condenser is tested by one of the alternative methods described later.

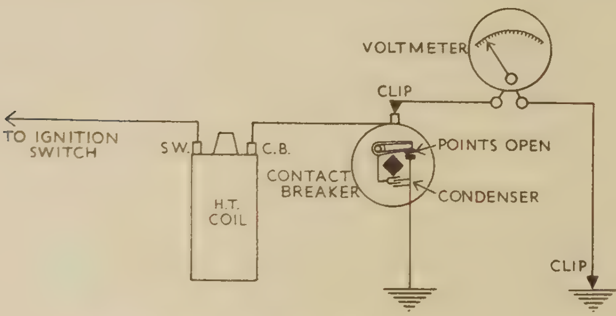


Fig. 28.—Testing for Faulty Coil-distributor Cable.

Complete Low-tension Circuit Test.—For the purpose of this test it is necessary to connect a test ammeter of 0 to 30 amperes range between the ignition switch and the S.W. terminal of the H.T. coil (Fig. 29), so that the current flowing through the circuit can be measured under different conditions. Here it should be mentioned that this method is adopted for Bedford commercial vehicles and it enables low-tension circuit troubles to be traced quickly. The distributor cap should then be removed and the engine cranked by means of the starting handle until the contact-breaker points are fully open.

Next switch on the ignition, when *no current reading should be shown* on the ammeter—since the low-tension circuit is broken.

If a reading is given this indicates a short-circuit to earth in some part of the ignition system. The most probable causes for this will be traceable from the following:

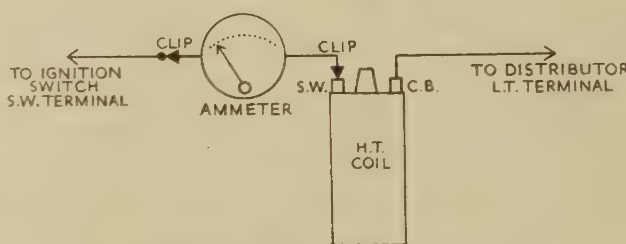


Fig. 29.—Making a Complete Low-tension Circuit Test.

(1) If there is current shown when the low-tension cable is disconnected from the H.T. coil C.B. terminal, the cause is an internal earth in the coil primary winding.

(2) If current is shown with the low-tension cable connected to the C.B. terminal but disconnected from the distributor low-tension terminal, the cause will be the earthing of the low-tension cable.

(3) If current is shown when the low-tension cable is connected to the C.B. terminal but when the cable is disconnected from the

distributor the ammeter ceases to give a reading, this signifies a defective condenser.

Tests with Contacts Closed.—If the engine is cranked until the contact-breaker points are closed, the ammeter should give a definite current reading, the value of which will depend upon what type (voltage) of battery is fitted and the particular ignition wiring or circuit used. In a typical 6-volt battery circuit the ammeter would read from 4·5 to 5 amperes, and in a 12-volt one, 2·25 to 2·75 amperes. If the actual readings are high or low, the causes will be as follows:

(*A*) *High Reading:* Primary circuit of H.T. coil short-circuited.

(*B*) *Low Reading:* High resistance due to H.T. coil to distributor cable and its connections or to defective contact-breaker points.

Testing the High-tension Circuit

If after testing the coil-ignition circuit the results indicate that it is the high-tension circuit that may be at fault, the following possible causes of *total failure* should be investigated:

(1) The high-tension (H.T.) coil. (2) The H.T. cable from coil to distributor. (3) The distributor unit. It is very unlikely that all the sparking plugs or their leads from the distributor would be defective at the same time, so that we have omitted these in the present considerations.

Testing the H.T. Coil.—The most likely causes of failure are: (*a*) the breaking of the low-tension windings, causing an open circuit; (*b*) short-circuiting of the low-tension windings; (*c*) breaking of the high-tension windings; (*d*) short-circuiting of high-tension windings. The possible causes (*a*) and (*c*) may be due to broken connections at the terminals.

To check for *broken low-tension windings* without removing the coil from the engine, it is only necessary to attempt to pass a low-tension (battery) current through the primary coil, using a suitable voltmeter. The method used in testing the modern Vauxhall car ignition system is shown in Fig. 27. Here a two-range voltmeter is connected between the contact-breaker, or C.B., terminal and the chassis frame (earth), using a spring clip on the end of the lead for this purpose.

If with the ignition switched on *the voltmeter shows no reading*, this indicates an open circuit in the low-tension winding.

If the voltmeter gives a low reading, namely less than 4 volts for a 6-volt battery and 8 volts for a 12-volt one, this shows that there *is a high resistance in the primary winding*, assuming good electrical contacts have been made in the rest of the test circuit.

Checking for a broken high-tension winding in the H.T. coil cannot be done satisfactorily with a low-voltage supply owing to the high resistance, namely 2,000 to 3,000 ohms; although a sensitive milliammeter would give a small reading. A good method is to use a higher voltage, such as that of a wireless dry battery (60 to 120 volts) in conjunction with a milli-

ammeter. If the latter fails to show a reading, this indicates a break in the high-tension winding.

Another simple method is to use a low-voltage supply, such as a small dry battery (4 volts) and a telephone receiver, connected up as shown in Fig. 30. If the high-tension winding is continuous then, upon "making" the circuit with the switch shown, *a distinct click* will be heard in the telephone receiver. If, however, there is a break in the winding, no click will be heard.

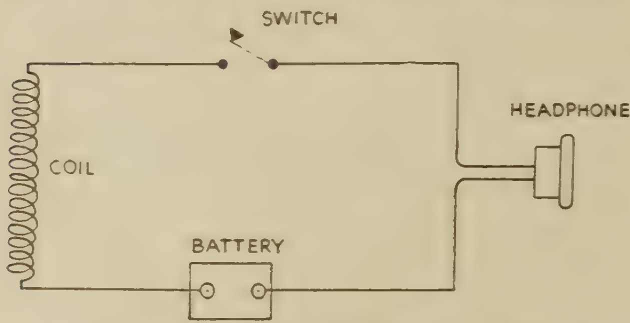


Fig. 30.—Method of Testing the High-tension Coil.

In regard to *the test of the low-tension winding*, if as mentioned earlier the voltage reading is lower than for the normal operating conditions, the cause may be defects in the distributor cable and its connections or to faulty contact-breaker points.

If, as a result of the H.T. coil tests, it is found that either the primary or secondary coils are open-circuited within the coil, the latter should be *replaced with a new coil.*

General Testing of the High-tension Circuit.—The possible sources of trouble in this circuit include the following:

(*a*) Faulty sparking plugs.
(*b*) Faulty (oil-soaked, frayed, or perished) H.T. cables to plugs from distributor head.
(*c*) Faulty cable from coil to distributor rotor.
(*d*) Bad connections at ends of H.T. cables.
(*e*) Faulty H.T. coil.
(*f*) Faulty distributor unit.

A careful examination of each H.T cable will reveal whether it is frayed, perished, or has chafed through so as to allow the high-tension current to leak to the low-tension side of the circuit or to earth.

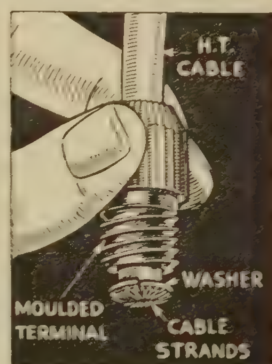


Fig. 31.—The Lucas High-tension Terminal.

Making H.T. Cable Connections.—The cable connections to the distributor should also be checked for good electrical contact. The correct method for Lucas coils to make the high-tension lead connection is as follows: thread the knurled, moulded terminal over the outside of the cable. Bare the end of the cable for about $\frac{1}{4}$ in. and thread the wires through the brass washer provided. Then bend back the wires, as shown in Fig. 31, and finally screw down the moulded terminal nut securely.

Testing the Circuit with Sparkmeter.—A useful and essential device for checking the high-tension circuit is that known as a *sparkmeter*. It consists of a pair of pointed rods, one of which is fixed to its bracket, and the other is screwed in order to vary the distance between the points. The pointed rods are insulated from one another by mounting their brackets on a block of ebonite or other insulating material, and the brackets are electrically connected to terminals. The moving rod should be provided with a millimetre scale to show the distance between the two points, i.e. the air gap.

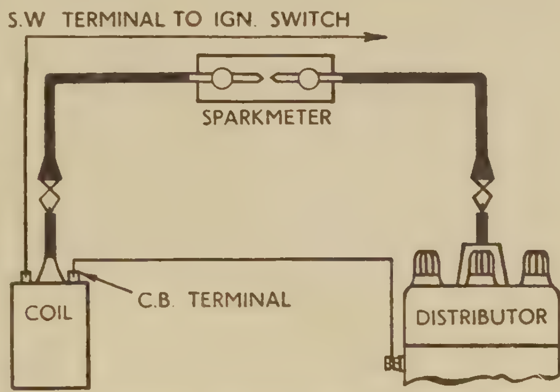


Fig. 32.—Sparkmeter connected in Series with the H.T. Coil and Distributor.

The method of using this device is to connect it in series with the high-tension cable concerned in the tests. Fig. 32 shows the sparkmeter connected in series with the H.T. coil and distributor cable for the purpose of checking the high-tension circuit by the method developed by the Vauxhall Motor Co., Ltd., for their cars and commercial vehicles.

For the purpose of this test, the ordinary cable from the H.T. coil high-tension terminal to the rotor-connected central terminal of the distributor is removed and replaced by one having the sparkmeter inserted, as shown in Fig. 32. The sparkmeter gap is closed so that the points touch, and the engine is started and run at a fast idling speed. The sparkmeter gap is then opened, gradually, by means of an insulated knob provided, until the spark is about to fail.

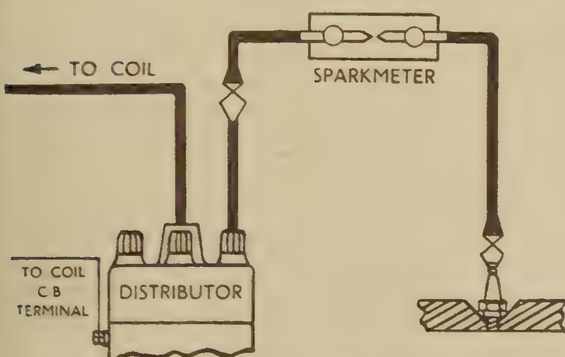


Fig. 33.—Sparkmeter connected in Series with Sparking Plug.

The engine is then stopped and the sparkmeter cable replaced by the normal high-tension cable between the H.T. coil and distributor. The sparkmeter is then connected in series with each of the sparking plugs in turn (Fig. 33) and the engine run as before. If there is any high-tension current leakage, the loss of voltage will cause the spark to fail. This will indicate a *faulty cable*, *distributor cap*, or *rotor arm*.

The Three-point Test Gap

Whilst the two-point spark gap is very useful for the general test purposes described, it does not afford an accurate measure of the sparking voltage under normal operating conditions within the engine cylinder. Without delving into the electronic theory of ionisation, it is here sufficient to state that the gas surrounding the sparking-plug points becomes a conductor of electricity by a process known as *ionisation*, and that within the combustion chamber owing to the working conditions such ionisation conditions exist, whereas there are none between a pair of sparking points in air or when the air is compressed—as in test chambers of plugs. Not only are the sparking voltages higher, but the values are unreliable in the latter case. Ionisation can be introduced by the presence of a third pointed electrode, arranged, as shown in Fig. 34, so as to have its axis at right angles to the main sparking points and its point behind the main sparking point shown by about $\frac{15}{1000}$ to $\frac{20}{1000}$ in. The actual gap is only a few thousandths of an inch, and can be found experimentally if the third point is made adjustable. When properly adjusted, this *completely insulated* third point should produce a very small spark across its gap; this produces the necessary ionisation conditions required. The main spark gap should be adjustable by providing the left-hand point with a fine-pitched screw and nut device. This adjustable point should be earthed and the other one connected to the high-tension source of supply. If the gap is set at 5 mm., the voltage required to bridge this gap will be about 8,000; for a 6-mm. gap it is about 10,000, and for an 8-mm. gap about 15,000. Thus the width of the gap across which a spark will just pass under ionisation conditions can be used as a measure of the sparking voltage in ignition-apparatus tests.

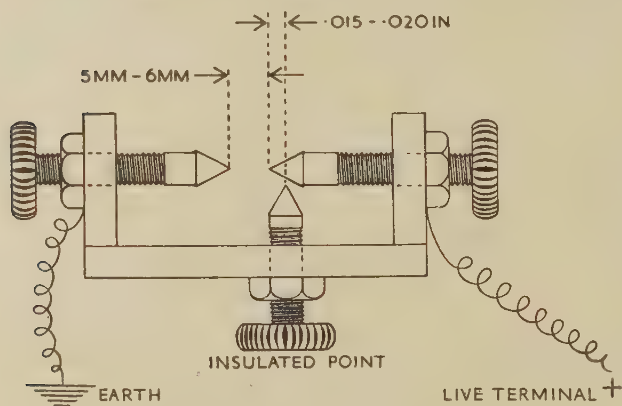


Fig. 34.—The Three-point Test Gap.

There is another spark-gap tester consisting of three $\frac{1}{4}$-in. diameter hard-steel balls instead of sparking points, which burn away fairly quickly, whereas the balls have a much longer life; they require a rather higher sparking voltage for a given gap than the pointed spark tester.

Another spark tester used for routine ignition tests consists of a nickel wire of about 18 S.W.G. arranged concentrically with a round brass plate having a $\frac{1}{4}$-in. diameter hole, thus giving a gap of about 6 mm. This device has a much longer " sparking " life than the three-point tester.

The Distributor Cap.—This cap, of moulded composition, is held on to the contact-breaker moulded casing by means of a pair of spring clips that can readily be disconnected and hinged downwards to allow the cap to be removed. A typical design of cap is shown in the upper portion of Fig. 50, on page 50. Inside the cap at regular intervals are the metal contacts or segments to which the plug cables are connected. The high-tension current from the H.T. coil cable is led to a spring-loaded carbon brush, which makes light contact with the metal on top of the rotor arm, thus supplying the latter with high-tension current. The end of the rotor arm (Fig. 35) is hook-shaped and the arm rotates in the direction denoted by the arrow. The metal hook member does not make metallic contact with the metal segments in the distributor cap, but passes very close to these as it rotates, so that a high-tension spark leaps across the narrow gap to the plug-cable contacts. This "jump-spark" method of high-tension current

Fig. 35.—Shape of Brass Plate on Rotor Arm.

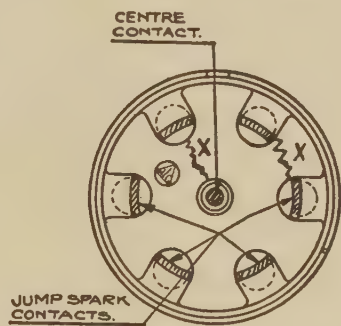


Fig. 36.—Distributor Cap tracking Faults (indicated as X).

distribution is a distinct improvement on the previous wipe or solid-contact method, as there is no wear due to friction. The usual gap is of the order of ·015 to ·020 in.

Faults liable to occur with the distributor are as follows, namely: (*a*) *erosion* or melting away of *the metal at the end of the rotor* or of the segments, according to the earthing of the positive or negative pole of the battery; (*b*) *partial breakdown* due to *much dirt and*/or *oil* inside or outside the distributor cap; (*c*) *tracking effects* due to the high-tension current forming a conducting path between adjacent segments or between the central electrode and one of the segments.

The distributor cap should be thoroughly cleaned with a rag moistened with petrol, all dust and oily deposits being wiped off. It should then be examined for tracking. This defect is revealed by the presence of a thin, black, somewhat irregular line between the metal segments or central electrode, as indicated at X in Fig. 36. The high-tension current then takes this path between the segments instead of its normal one through the sparking plugs, and misfiring will occur. The presence of fine cracks can

be revealed by the *cessation of sparking across the sparkmeter gap* when it is connected to the different segment electrodes of the distributor cap.

It is not satisfactory to attempt to remove these tracks with an abrasive paper, as the cracks are usually deep, and any roughening of the polished moulded material surface would promote further tracking. A temporary cure may, however, be effected by drilling two or three $\frac{3}{32}$-in. holes so as to interrupt the track. The only satisfactory cure, however, is to fit a new cap.

Ventilation of the distributor cap is essential, since one result of employing the jump-spark method is the production of a conducting nitrous powder as a result of oxygen and nitric-acid formation due to the ionisation caused by the sparking. Periodical cleaning with a water-moistened cloth will eliminate this powder, as it is soluble in water. Modern distributor caps are provided with small ventilation holes to help get rid of the ionisation products.

The Rotor Gap.—If this gap becomes excessive as a result of sparking erosion, a greater voltage will be necessary to bridge the gap. The checking of the gap is somewhat difficult, although if the centre of rotation of the rotor arm be found by means of a fixed scriber, whilst the engine or distributor camshaft be rotated by hand, it is possible to deduce the clearance by subtracting the rotor radius from the internal radius of the cap, as measured between the segments. Usually, however, a careful examination of the metal at the end of the rotor, and also that of the segments at the sparking places, will reveal the necessity or otherwise of effecting a change of rotor arm.

The Condenser

The condenser, referred to previously as being connected across the contact-breaker points, performs two very useful functions; namely: (1) it prevents arcing or sparking between the contacts when the latter separate to "break" the primary or low-tension circuit, and (2) it produces a higher and more uniform voltage at the sparking-plug points.

When the contacts are closed the condenser is not affected, but when the engine is operating and the contacts open an increasing electromotive force is induced in the primary winding, and the condenser, across the contacts, becomes charged with electricity, thus preventing the surge of current across the contact-breaker gap and therefore reducing the tendency to spark. Also the current in the primary coil falls more rapidly than it would do without the condenser, and it is this more sudden fall or flux diminution that results in the higher secondary circuit voltage. The condenser connections are shown in Fig. 19 on page 25.

The condenser cannot pass direct current, but acts as an electrical energy store when voltage is applied to its terminals. When the latter are connected by means of a conductor, the condenser is discharged.

Possible Condenser Faults.—There are four possible types of faults

which may cause poor condenser performance or failure; namely: (1) breakdown of the insulation or internal shorting of the two sets of plates; (2) low insulation resistance or internal leakage which prevents the condenser holding its charge; (3) high series resistance due to defective lead or bad electrical connection; (4) incorrect capacity for circuit. Of these faults, (1) and (2) are the more common ones.

If the condenser is short-circuited, the primary current will not be interrupted when the contacts open, and no spark will occur at the plug points, since the primary current will flow direct to earth through the condenser.

If the condenser does not hold its charge, there will be arcing across the contacts, and these will soon become pitted.

Items (3) and (4) require special test equipment to detect.

To test the condenser for short-circuiting one can use test prods, as shown in Fig. 37, in conjunction with a direct-current source of electricity of at least 90–100 volts.

A suitable test light is connected in series with one of the point leads and the condenser is momentarily connected into the circuit with the points, since it is supposed to hold an electrical charge when in good condition. If the unit is in good condition, the circuit remains incomplete and the lamp will not glow. If the lamp does glow the condenser is defective.

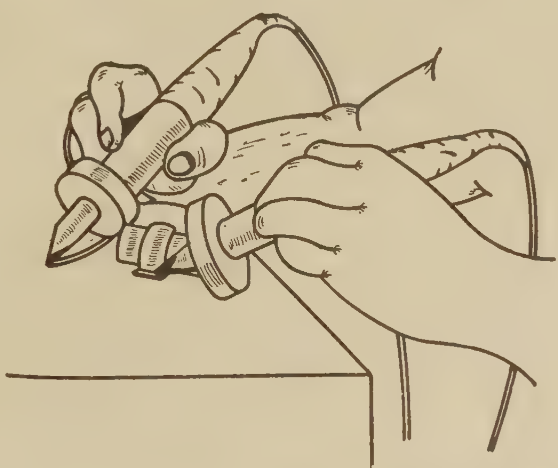


Fig. 37.—Method of Testing a Condenser by means of Two Metal Points, in Insulated Holders, connected to a Lamp.

This test charges the condenser, and the next step is to determine whether the condenser will hold this charge for a short time. To make this discharge test, remove the test points and connect a wire or metal object, such as a screw-driver, across the condenser terminals. If the unit is in good condition, a short, snappy spark should be obtained. This spark should produce a sound similar to the cracking of a small whip. The discharge test can also be made as shown in the illustration at Fig. 38, the lead or pig-tail being brought within $\frac{1}{64}$ in. of the ground strap. A snap spark should be obtained if the condenser is in good condition.

Direct current is preferable for these tests, although satisfactory results can be obtained with alternating current, but a spark will not be obtained every time a discharge test is made.

Another method, which uses the test circuit shown in Fig. 28, is first to make certain that the cable from the C.B. terminal of the H.T. coil to the distributor casing is sound. With the ignition switched on and the contact-

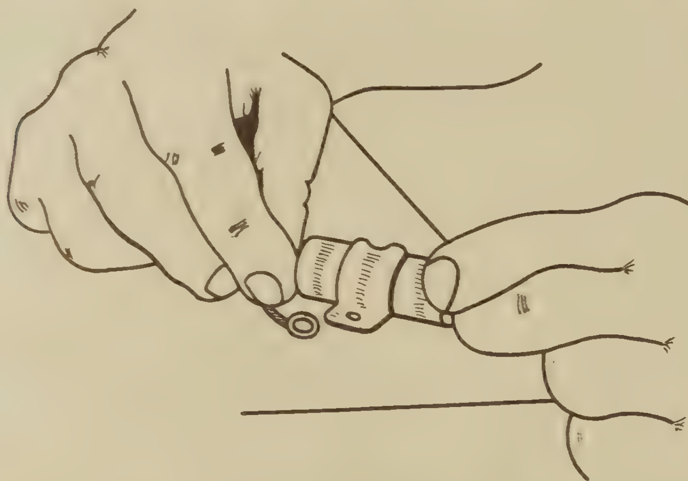


Fig. 38.—The Condenser-discharge Test Method.

breaker points open, if the voltmeter reading is appreciably below the full battery voltage this indicates a faulty condenser.

The condensers of coil-ignition units and also magnetos can be tested by means of the simple apparatus shown in Fig. 39.

Here we have a double-pole, double-throw switch arranged in the ordinary lighting mains circuit, and a lamp connected in series with the condenser under test.

If when the switch handle is thrown over to the "on" position the lamp lights up, this proves that the condenser is faulty, i.e. its plates are touching.

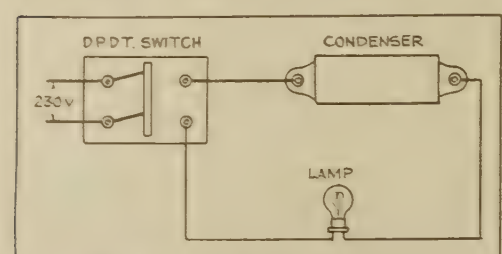


Fig. 39.—Testing Ignition Condenser.

If, however, the lamp fails to light, the condenser insulation is shown, thereby, to be intact.

Finally, in order to show that there is no actual break in either of the terminal connections to the condenser plates, the two terminals should be momentarily short-circuited with an insulated handle screw-driver. If a spark occurs, the condenser is satisfactory. Before carrying out this test the condenser should be charged up by placing in the apparatus shown in Fig. 39 and closing the switch.

When the Switch is left "On"

There is one particularly interesting point about the resistance unit on certain coil-ignition systems, viz. should the engine be stopped and the

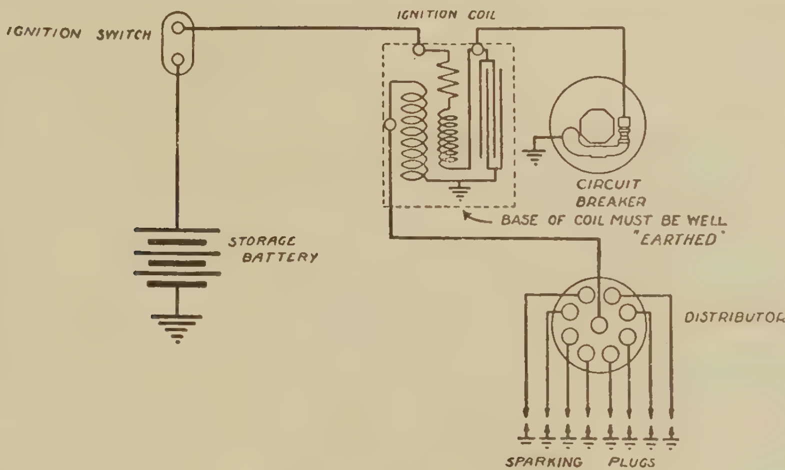


Fig. 40.—Coil-ignition Layout for an Eight-cylinder Engine.

switch left " on," the battery will only discharge very slowly owing to the high resistance of this device; usually it will take from one to two days before the battery is seriously depleted.

General Tests of Contact-breaker Distributor Unit

The complete distributor unit, including the contact breaker with its automatic advance mechanism, can be tested with the aid of an apparatus known as a *synchroscope*, of which there are several commercial models, a typical one being shown in Fig. 41. The principle of these devices is that of a variable-speed mains-driven electric motor having an accurate speed indicator, which drives the contact-breaker camshaft, the unit being removed from the engine for this purpose. An insulated circular scale, graduated in degrees, is mounted concentrically to the motor shaft drive, and a metal pointer secured to the shaft rotates close to this circular scale. When tests are made sparks jump across from the tip of the pointer to the scale, and the latter shows the exact angular positions at which these sparks occur.

With the aid of this apparatus for routine testing of ignition equipment, any faults in the system can readily be diagnosed. Thus it is possible to test the contact-breaker advance mechanism, wear of the cam-spindle bearings, wear of the lobes on the cam, and other faults, by the character and position of the rotating pointer's sparks. Further, it is possible to

obtain readings of automatic ignition advance angles and engine speeds in order to check the ignition timing at all speeds.

The synchroscope with distributor unit mounted up for test[1] (Fig. 41) is provided with a self-centring chuck for holding and driving the camshaft. The procedure for testing the *centrifugal automatic advance* mechanism is as follows:

Having first ensured, by a preliminary run-up, that the governor weights are free and the spark returns to the initial setting or zero mark, and the distributor and its shaft are in proper alignment, run the motor and note that there should be as many equally spaced sparks per revolution of the pointer as there are cylinders, e.g. four sparks at 90° for a four-cylinder and six sparks at 60° for a six-cylinder engine.

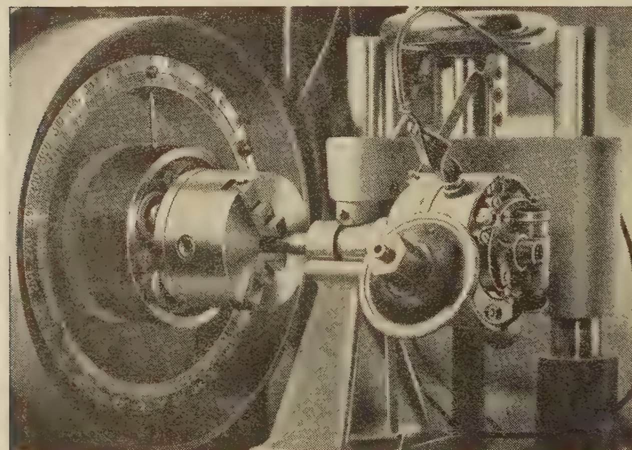


Fig. 41.—The Synchroscope, shown in use testing Bedford Ignition Unit.

The distributor, or the synchroscope scale, should first be adjusted so that when the motor is running at about 350 to 400 r.p.m. one of the sparks occurs opposite the zero of the scale; the automatic advance should not cut in at this speed. If the distributor unit is in good working condition each spark should occur within 2° of its correct angular position, namely 0°, 90°, 180°, and 270° for a four-cylinder engine and at 60° intervals for a six-cylinder one.

If the distributor unit is faulty this will be shown by the character of the sparks and their relative positions on the scales.

The various spark indications and their interpretations are shown in the following table:

SYNCHROSCOPE SPARK CHARACTERISTICS AND FAULT INDICATIONS

Spark Characteristic	*Cause, Fault, or Indication*
Regularly and evenly spaced	Distributor unit bearings and contact breaker in good condition.
Unevenly placed	Worn distributor spindle, or spindle bearings or spindle bent.
Multiple sparks	Points bounce. This usually occurs at certain fixed speeds.
Intermittent sparking at all sparking locations on scale	Dirty or pitted contacts or points not adjusted correctly.
One spark unevenly located	Worn or damaged cam lobe.

[*Vauxhall Motor Co. Ltd.*

[1] Courtesy the Vauxhall Motor Co., Ltd.

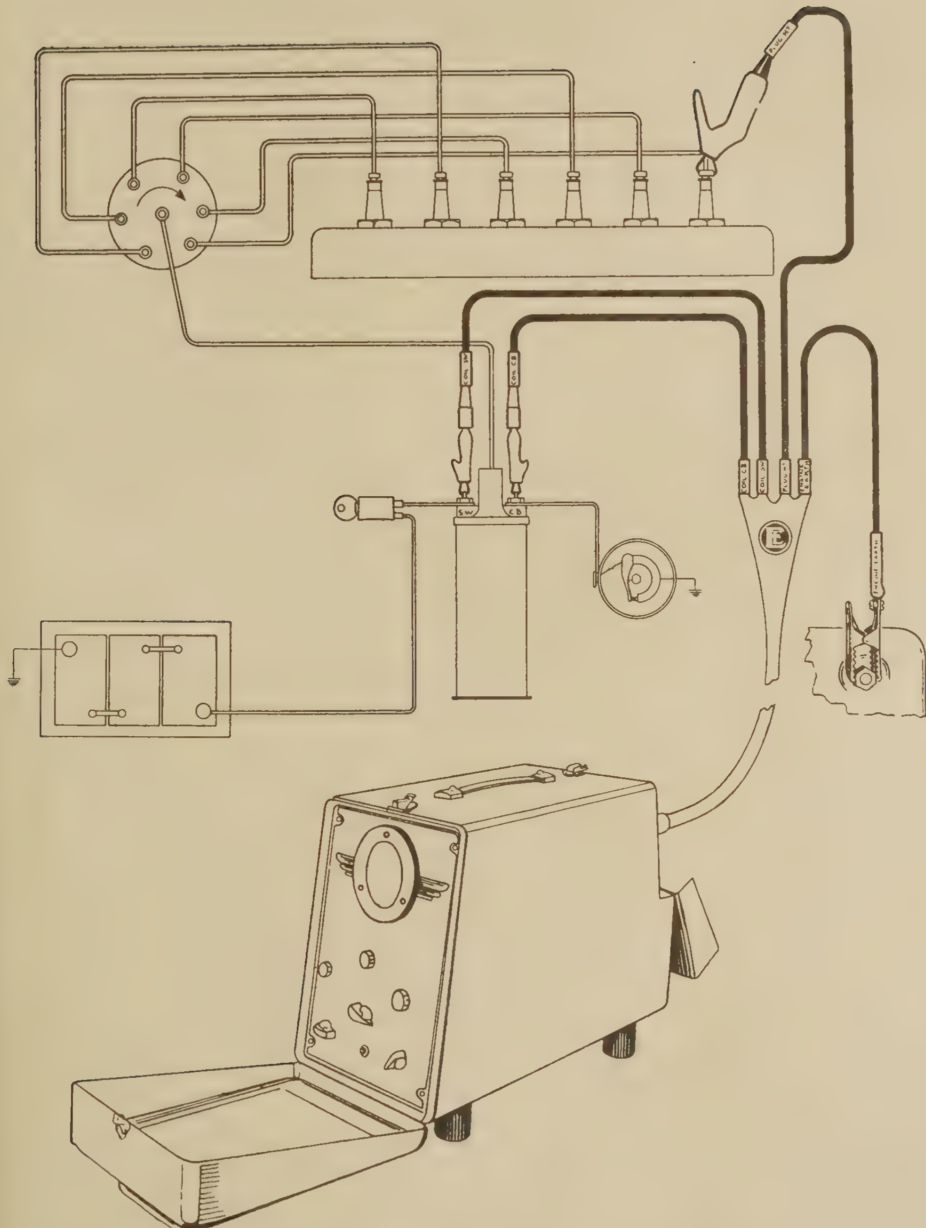


Fig 12.—General Layout of the Components of the English Electric Electronic Ignition Tester.

As the motor driving the cam spindle is gradually speeded up, the automatic advance mechanism will come into operation; usually at about 500 r.p.m. Readings of the spark angle on the scale should be noted down every 200 r.p.m. increase, and after the maximum speed of 2,000 r.p.m.

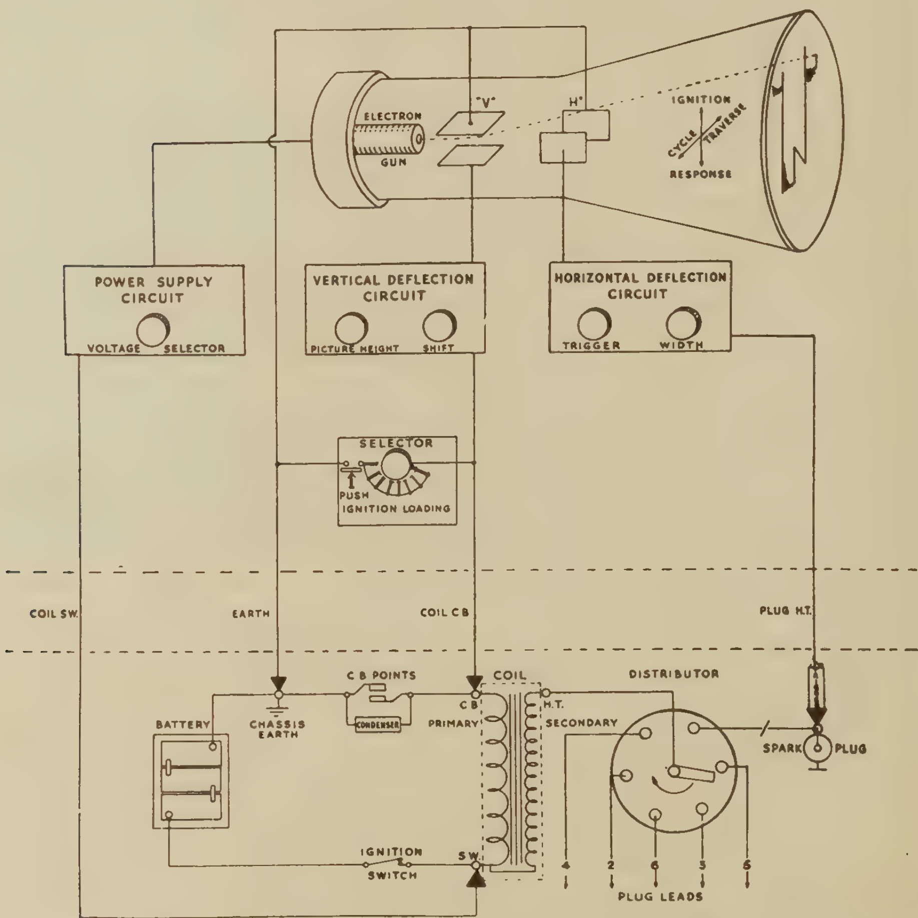


Fig. 43.—Illustrating the Principle of the English Electric Ignition Tester.

has been attained and the spark angle noted, the speed should be reduced gradually and another set of readings taken every 200 r.p.m. If the centrifugal mechanism is operating satisfactorily there should be about a 2° advance for every 200 r.p.m. speed increase up to a maximum of 12° at 1,800 and also at 2,000 r.p.m. If the readings or graph made from these differs appreciably from these values, it is an indication of weak springs or wear in the centrifugal advance mechanism.

An Electronic Ignition Tester

The English Electric electronic ignition-testing apparatus, shown schematically in Fig. 42, enables the electrical characteristics of the ignition system to be seen on the surface of a cathode-ray tube resembling a small television picture screen. It shows the primary circuit voltage changes on a time base whilst the engine is actually operating, and an examination of the screen image by reference to standard cathode-ray tube diagrams enables any fault in the ignition system to be detected at once.

Referring to Fig. 43, which illustrates the principle, the tube may be regarded as an electronic gun which collects and projects a beam of electrons on the fluorescent screen on which, at the point where the electrons impinge, a bright spot is produced. The beam passes between two sets of deflector plates mounted at right angles and denoted by "V" and "H" in Fig. 43. The plates V are connected to the earth and the C.B. (contact-breaker) terminal of the H.T. coil. When the ignition system is operating, the voltage changes which occur between these points cause corresponding vertical deflections of the electronic beam. The plates H in the horizontal deflection circuit cause the beam to sweep from left to right, i.e. they cause the voltage changes to become spread laterally on a time base. The cycle used is that between each firing point of the selected sparking plug, namely that to which the instrument high-tension lead has been attached. In Fig. 42 this connection is marked on the extreme right above the " spark plug."

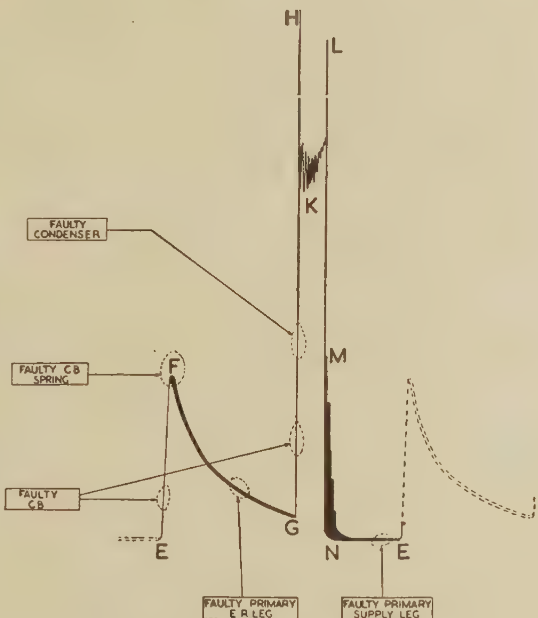
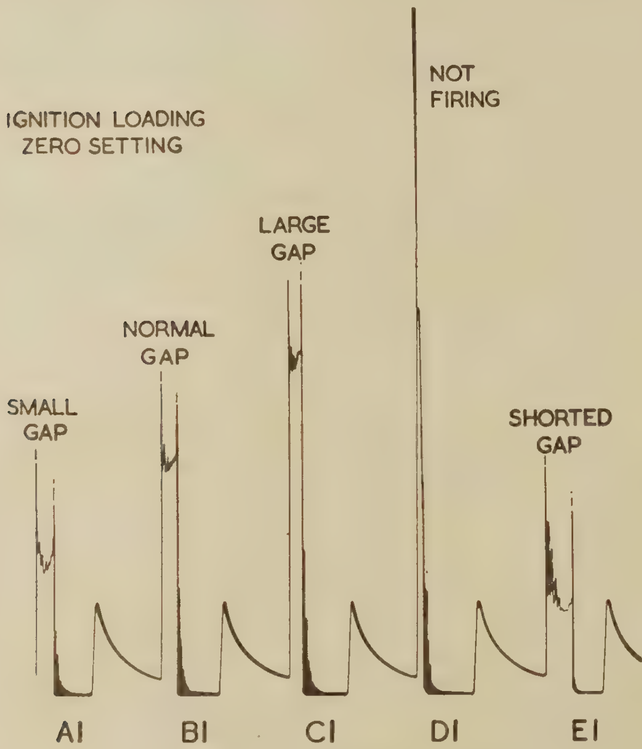


Fig. 44.—Characteristics of a Complete Firing Cycle, shown by Electronic Ignition Tester.

There are only four connections between the apparatus and the ignition system, namely at the S.W. and C.B. terminals of the H.T. coil, at any sparking-plug terminal, and at any convenient earth point on the engine. It should here be mentioned that when operating normally the ignition voltage cycles of all the cylinders are shown on the screen, so that it is immaterial which sparking plug is used for the apparatus high-tension connection.

In order to interpret the screen diagrams it is necessary to understand

the characteristics of a complete cylinder firing cycle; a typical example is shown in Fig. 44. The time of the cycle is represented between the points EE on the diagram. At E the contact-breaker points close, and they remain closed over EFG. Just after the points close there is a rise of voltage from E to F in the primary circuit followed by a decrease along F. to G. At G the contact-breaker points open and there is a sudden rise of voltage from G to H, when the plug commences to "fire." From H to K to L the plug continues to fire, with corresponding voltage fluctuations, but at L the plug ceases to fire, the last part of the graph LMN representing the final decay of voltage in the circuit. Finally, at E the contacts close again and the succeeding cycle commences, giving a similar voltage graph.



Fi . 45.—Various Sparking-plug Faults shown by Cathode-ray Screen Diagrams.

By comparison of the diagrams for the various cylinders with the standard ones, various ignition faults can be detected. Thus the diagrams corresponding to different sparking-plug faults, compared to those of the normal gap sound plug—the second from the left in Fig. 45—enable these faults to be detected at once whilst the engine is running.

Similarly, with a knowledge of the characteristic ignition diagram, previously described, various ignition faults concerned with the distributor are readily dignosed. Some typical faults are illustrated in Fig. 46.

Most ignition faults develop gradually and will not affect the engine performance until a breakdown or misfiring occurs. These faults can, however, be ascertained and rectified before breakdown occurs, and therefore the ignition system can be routine-tested with this apparatus whilst operating normally. There is, however, a special feature of this apparatus, namely *an electrical loading device*, which artificially reduces the energy in the ignition circuit under test, and thus finds out the weak spots. The loading

control is operated progressively until the plugs misfire, when the reading on the loading indicator and dial give a measure of the margin of reserve.

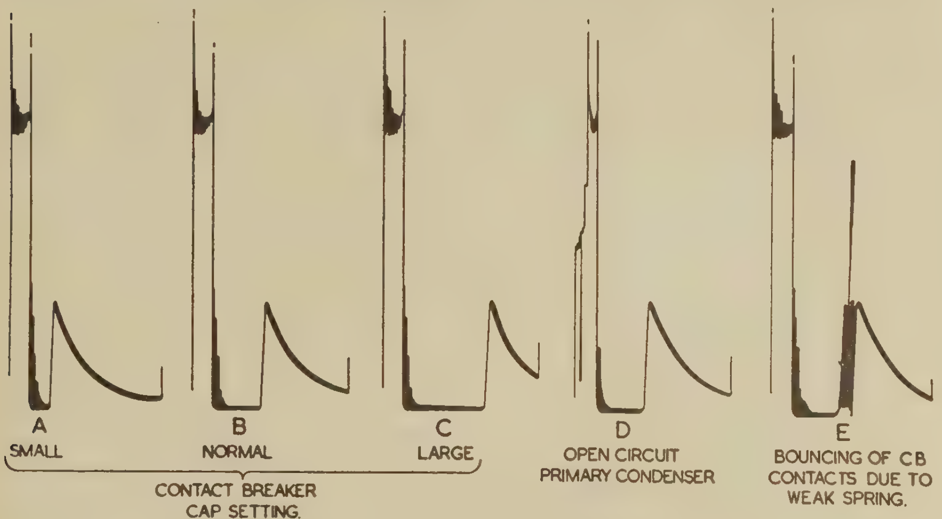


Fig. 46.—Typical Ignition Faults as indicated by the Screen Diagrams.

Lucas Coil-ignition System

The most widely adopted coil-ignition system for mass-produced cars in this country is that developed by Messrs. J. Lucas, Ltd., of Birmingham.

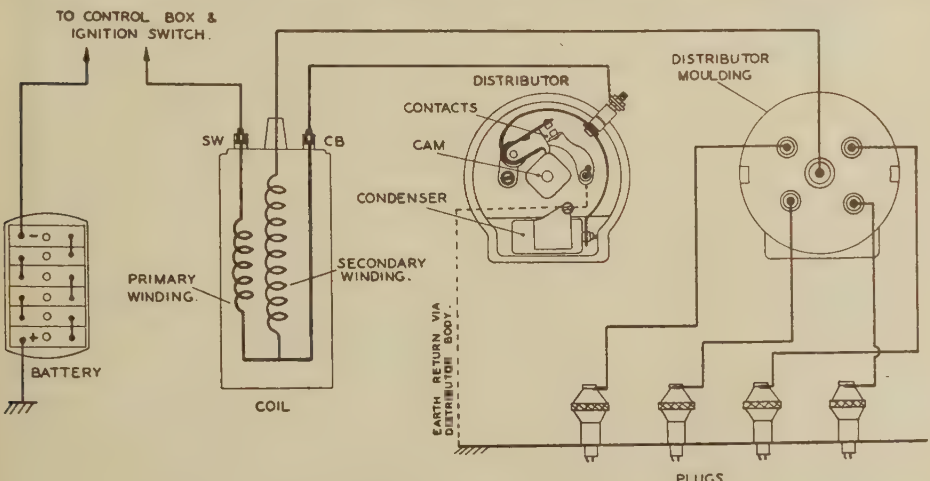


Fig. 47.—The Lucas Coil-ignition System for Four-cylinder Engines.

The general arrangement of a 12-volt coil-ignition system for a four-cylinder engine, adopted by the firm in question, is that shown in Fig. 47.

The positive pole of the battery is earthed, as in all modern electrical systems. The negative battery connection is taken to the ignition switch and back from the latter to the S.W. terminal of the H.T. coil; the switch enables the current from the battery to the S.W. connection to be broken for stopping the engine. From the C.B. terminal a low-tension lead is taken to the insulated member, namely the rocking lever, of the contact breaker and to one side of the fixed condenser.

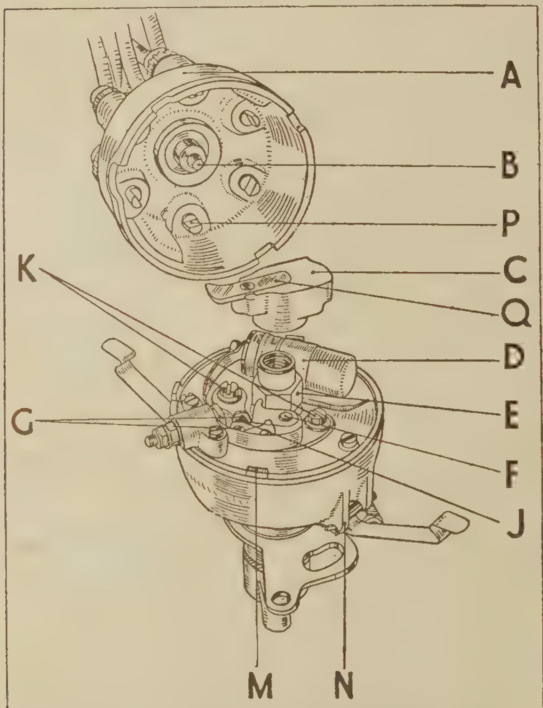


Fig. 48.—The Coil-ignition Unit (Armstrong-Siddeley).

A, Distributor Moulding.
B, Carbon Brush.
C, Rotating Arm (rotor).
D, Fixed Condenser.
E, Operating Cam.
F, Contact-breaker Arm Pivot.
G, Contact Points.
J, Contact-points Gap.
K, Screws for Contact Plate.
M, Oil Well for Automatic Advance Mechanism.
N, Hinge for Cover Clip.
P, Plug Cable Contacts.
Q, Metal Conductor

Although the actual coil windings are concentric in actual coils, they have been shown separate in Fig. 47, for explanatory purposes.

The Distributor and Contact-breaker Unit

The two principal components of the coil-ignition equipment are the combined distributor and contact-breaker unit with the engine shaft drive and H.T. coil.

The former assembly consists of two main units, namely: (1) the contact breaker and (2) the distributor. The first unit comprises the engine shaft drive which operates at one-half crankshaft speed, i.e. at camshaft speed; the cam at its outer end, for operating the moving arm of the contact breaker; the automatic centrifugal ignition advance device and the fixed condenser which is connected across the contact-breaker points. The distributor unit includes the rotor arm which fits into the end of the engine shaft—just beyond the cam—and the moulded distributor cover containing the contacts that take the high-tension current through each of the H.T. cables in turn to the individual sparking plugs. The high-tension current from the H.T. coil is taken by a heavy cable from the coil to the centre of the casing, whence it flows through a carbon brush (shown at B in Fig. 48) to the metal arm Q fixed to the top of the insulated rotor arm C. As the latter rotates at one-half engine speed the spark jumps across to each of the brass

USING THE ENGLISH ELECTRIC IGNITION TESTER OUTSIDE A GARAGE. THE OPERATOR IS SEEN FILLING IN ESTIMATE AND IGNITION REPORT CARD WHILST THE CUSTOMER WAITS.

segments in the distributing casing. Since the sparking-plug cables are attached to these brass segments the sparks occur at the sparking plugs each time the metal arm of the rotor comes opposite each segment. Each revolution of the rotor gives as many sparks as the number of cylinders of the engine. The distributor unit, normally held to the contact-breaker unit by means of two hinged steel springs, is shown removed from the latter unit in order to disclose the interior components.

The Contact Breaker consists of one fixed tungsten contact and one movable contact which is forced away from the fixed contact each time the lobe of the engine-driven cam comes opposite the rubbing part of the contact. The camshaft portion of the engine-driven operating shaft extension consists of a number of lobes or projections formed by making flats on a cylindrical shaft, so as to leave radiused portions constituting the cams.

Number of Lobes.—In the case of coil-ignition unit drive shafts running at one-half engine, or camshaft, speed, the *number of lobes* on the ignition unit camshaft is the same as the number of cylinders of the engine. Thus, there will be four lobes for a four-cylinder engine and six lobes for a six-cylinder one. If, however, there are *two contact-breaker units* on opposite sides of the camshaft, then the number of lobes is one-half that of a single contact-breaker unit. The double contact-breaker method is often used for eight- and twelve-cylinder engines.

It is useful to remember that for camshaft-speed drive shafts to the ignition units, *the number of lobes is equal to the number of brass segments of the distributor units* for single contact-breaker units.

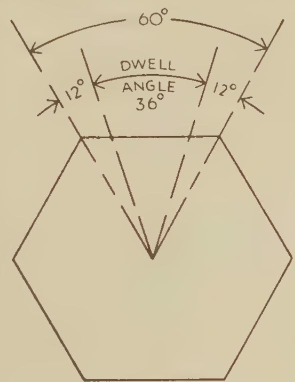


Fig. 49.

Contact-breaker Cam Angle or "Dwell."—It is important from the viewpoint of efficient engine operation, fuel economy, and maximum performance to maintain the correct period during which the contact-breaker points remain closed, since during this period the H.T. coil becomes energised, i.e. it builds up the maximum magnetic lines of force through the iron core. This period of time should be sufficient to enable the iron core to become saturated. The actual period depends upon (1) the designed cam angle, (2) the contact-breaker opening or gap. Fig. 49 illustrates a six-cylinder engine six-lobe cam, and shows the cam angle or "dwell" to be about 36°. This angle on the camshaft shows the angular period during which the contacts remain closed.

If the "dwell" period is too small—as when the cam is worn or the contacts have too great an opening—the coil will not become sufficiently energised and lower primary and secondary voltages will occur, giving weaker sparks at the plugs.

the "dwell" period is too great—as when the contact-breaker gap is too

small or the engine runs at low speeds—the increased current will be detrimental to the contacts.

To Check the " Dwell " Period.—This period may be measured with the proper electrical bench equipment, which has a dial for indicating the " dwell " angle. A *syncroscope* apparatus can be employed for this test.

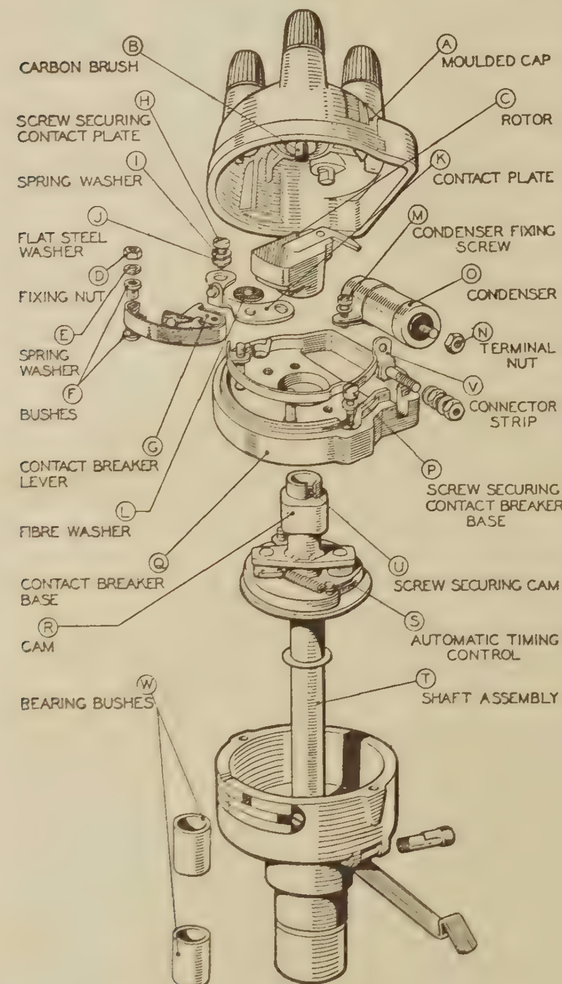


Fig. 50.—Dismantling Lucas Distributor.

With special test equipment, the "dwell" angle can be measured as follows: connect a test lamp of the same voltage as the battery (6 volts or 12 volts) between the primary terminal of the distributor and any convenient earth point. Loosen or remove the sparking plugs to enable the engine to be hand cranked slowly and easily. Then turn the crankshaft slowly and, when the contacts have opened, continue turning until they close. Mark the rim of the flywheel with a scriber opposite some fixed mark on the crankcase (or the usual T.D.C. pointer or mark), and continue turning until the contacts open again. Then mark the flywheel rim again. The angular distance between the scriber marks give the *angle of "dwell"*; for a six-cylinder engine this angle should lie between 34° and 38°.

Dismantling the Lucas Distributor Unit

The partly dismantled Lucas coil-ignition distributor unit is illustrated in Fig. 50, the main components being indicated in this diagram. A partly-dismantled distributor unit is also given in Fig. 62, on page 63, in the case of one of the post-war Austin cars. The method of dismantling the unit (Fig. 50) is as follows:

(*a*) Spring back the securing clips and remove the moulded cap A.

(*b*) Lift the rotor C off the top of the spindle. If a tight fit lever carefully with a screw-driver.

(*c*) To remove the moving contact, unscrew the nut D, securing the end of the spring; lift off the spring washer E and bush F and remove the contact-breaker lever G. Take out the two screws H, complete with the spring washers I and flat steel washers J, from the plate K, carrying the fixed contact and remove the plate.

(*d*) Undo the two screws P fitted at the edge of the contact-breaker base L and lift out both with their spring washers. The contact-breaker base can then be removed from the body of the distributor.

(*e*) Take out the screw M from the condenser clip. Unscrew the terminal nut N, lift off the spring washer and remove condenser O.

(*f*) Remove the driving gear from the shaft by tapping out the peg. In reassembling, the peg must be riveted over to secure the gear.

(*g*) Lift the cam R, automatic timing control S and shaft assembly T from the distributor. Take out the screw U from inside the top of the cam spindle and lift the cam off. The automatic timing control is then accessible.

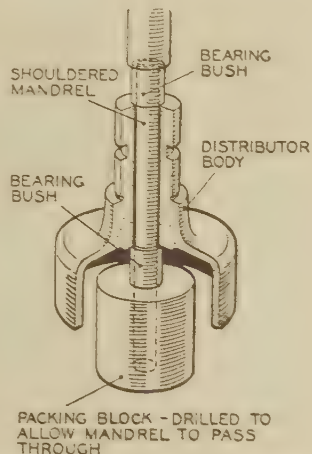


Fig. 51.—Renewing Distributor Bush.

Renewing Distributor-shaft Bearing Bushes

The procedure for the replacement of the distributor-shaft bushes is as follows:

(*a*) In order to ensure easy running of the distributor shaft when the shank has been rebushed, the new bushes must be fitted so that they are in correct alignment. The bushes must be fitted by means of a vertical drilling machine or hand press using a mandrel and a packing block of the type illustrated in Fig. 51.

(*b*) Fit the mandrel in the drilling machine or hand press and place the distributor body in an inverted position on the table below it.

(*c*) To remove the bushes, a sleeve must be fitted over the mandrel to build it up to the required size. With this sleeve fitted in position, force the old bushes out of the shank by applying a steady pressure.

(*d*) Take the sleeve off the mandrel. Place one of the longer bushes on the mandrel, then the distributor body in an inverted position, and finally one of the smaller bushes.

(*e*) Locate the end of the mandrel through the packing piece and press the mandrel downwards, taking care that both bushes enter the distributor shank squarely. Continue forcing the bushes into the shank until the mandrel reaches the end of its travel.

(*f*) After fitting, the bushes must not be opened out by reaming or any other means, as this would tend to impair the porosity of the bushes and so prevent effective lubrication.

The B.T.H. Coil-ignition Equipment

This equipment is supplied for four- and six-cylinder cars on the 6- and 12-volt, earthed (single pole) or insulated (two pole), systems. It can be obtained with automatic timing advance. As it conforms to the S.M.M.T. dimensions, it is interchangeable with other British makes of coil-ignition apparatus. The usual equipment includes the B.T.H. Type C ignition coil and Type D distributor.

Fig. 52.—The B.T.H. H.T. Coil.

Ignition Coil.—The ignition coil (Fig. 52) is robustly constructed, and is especially designed to suit varying climatic conditions. The windings are thoroughly insulated, and are so arranged that a high factor of safety is obtained. The whole coil is mounted in a tubular container of insulating material, with a ballast resistance mounted on the top of the container; this ballast resistance is fitted to prevent damage to the windings and the rapid discharge of the battery should the ignition switch be inadvertently left on when the engine is stationary.

The Distributor Unit.—The distributor head comprises a cast-iron casing the stem portion of which constitutes the bearing for the driving spindle. Lubrication of the spindle bearing is provided by means of a grease cup secured in the casing; and spiral grooves in the bearing ensure that an adequate supply of lubricant is maintained throughout its length.

The components of the contact breaker are mounted on a base plate, located in, and screwed to, the cast-iron casing. A four- or six-point cam is suitably fixed to the end of the driving spindle, and co-operates with a fibre heel on a light, pressed-metal contact lever, to open and close the contact points. The period of closed circuit is timed to give excellent high-speed operation. The contact lever is mounted on a hard-steel pivot pin which is recessed to take an oil wick for lubricating the contact-lever bearing.

The distributor-brush holder is mounted on the end of the cam, and is provided with a nickel electrode of substantial dimensions. The electrode co-operates with nickel inserts in the distributor moulding, and so distributes the induced high-tension current to the sparking plugs. The distributor is neatly moulded in B.T.H. Fabrolite and secured by two strong spring clips to the cast-iron casing.

Maintenance Notes for B.T.H. Coil Ignition.—(1) The grease cup on the side of the body should be kept charged with " Belmoline " C grease or other good-quality soft grease. One turn given every 500 miles will ensure the main bearing being adequately lubricated.

(2) The contact-breaker lever pivot is hollow and provided with an oil wick. One or two drops of light oil should be allowed to drop into this every 2,000 or 3,000 miles. Care should be taken to remove any surplus oil from the lever in order that it does not get on the contacts.

(3) Occasionally the inside of the distributor should be wiped with a petrol-moistened cloth, and any carbon dust or foreign matter removed. The brush holder should be similarly treated at the same time.

(4) The contact gaps should be maintained at ·018 in. when fully open, and adjusted when necessary.

(5) All cables should be held tightly under the various terminals and any that become damaged in service should be replaced.

The Leyland Ignition System

The Leyland commercial petrol-engine vehicles are fitted with coil ignition when required as an alternative to magneto ignition.

For commercial-vehicle purposes this type has many advantages; starting in winter is much easier, thus eliminating starting-motor troubles.

The Leyland coil and distributor are shown in Fig. 53. In this case the distributor is of the semi-automatic type, the ignition being advanced automatically as the engine speed increases. This automatic advance is obtained by means of a centrifugal device located under the contact-breaker mechanism; as the engine speed increases the weights fly outwards against retaining springs, and in so doing rotate the cam relatively to the distributor shaft; this gives an earlier spark.

The distributor cap is of the side-entrance type, ensuring a positive connection between the high-tension leads and the metal inserts of the cap.

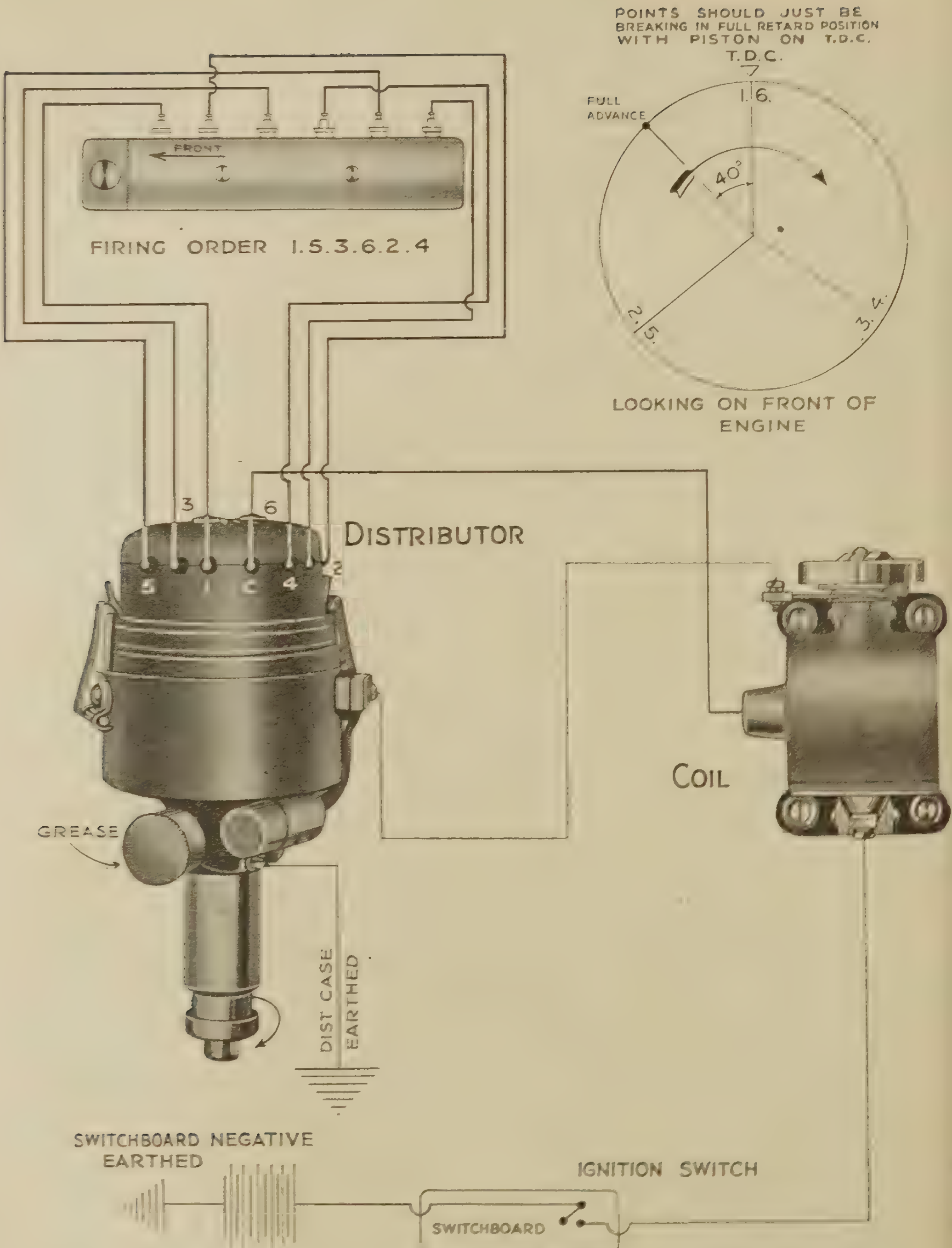


Fig. 53.—The Leyland Coil-ignition System Layout.

The coil transforms the low-tension battery voltage, viz. of 12 volts, up to about 7,000 volts at the sparking-plug points.

The distributor shaft shown below, on the left, in Fig. 53 runs at one-half engine speed.

Double Lever Contact-breaker Adjustment

Some distributors for six-cylinder engines, and all those for eight-cylinder engines, are of the double-lever type. Each lever operates for half the number of cylinders, a three- or four-lobe cam being fitted.

The distributor should be inspected and the two pairs of contacts A (Fig. 54) should be cleaned and the gaps between them checked as previously described.

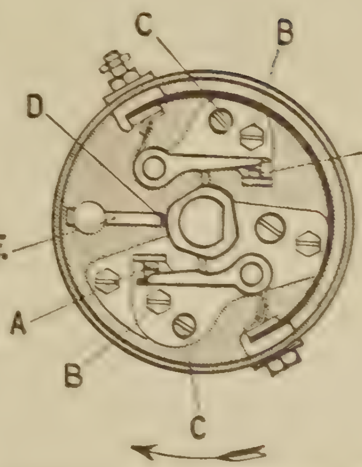


Fig. 54.—A Double Contact-breaker Unit used for Six-cylinder Engines.

A, Contacts.
B, Locking Screw.
C, Adjustment Screw.
D, Wick Lubricating Cam.
E, Oil Hole for Cam-lubricating Wick.

To adjust the gaps, proceed as follows: slowly turn the engine until one pair of contacts is seen to be fully opened. Then slacken the locking screw B and adjust the gap to the gauge by turning the adjusting screw C. After the adjustment, do not forget to tighten the locking screw. Adjust the other gap in the same way.

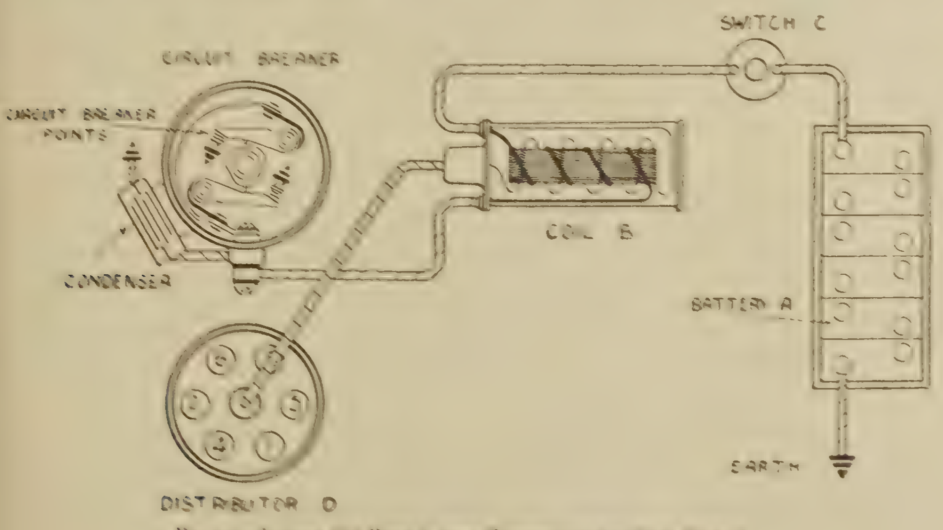


Fig. 55.—Layout of a Double-lever Contact-breaker Unit (Delco).

It is inadvisable to make any adjustment to the other screws in the contact breaker, which are locked. These are provided for synchronising the two contact-breaker levers.

It is important that both gaps are maintained to the gauge, as the two contact-breaker levers are synchronised at the works with the gaps accurately set. If the contact gaps are not correct, there will be a tendency for the timing of half the cylinders to be slightly different from the rest.

The method of adjusting and maintaining coil-ignition systems of commercial vehicles can best be illustrated by considering a typical example, namely that of the Leyland commercial-vehicle coil-ignition system mentioned above (Fig. 56).

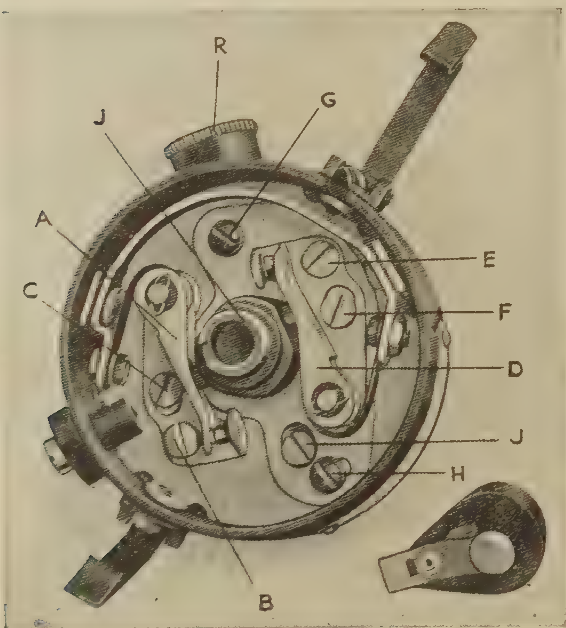


Fig. 56.—The Leyland Double-lever Contact-breaker Unit.

The only parts of the Leyland coil-ignition system requiring occasional adjustment are the contact-breaker points.

The gap between the points should be ·018 in. to ·024 in. when fully open. To adjust: loosen screw B (Fig. 56) and adjust screw C until the gap is ·022 in. (stationary points, breaker arm A). Turn engine until the rubbing block of the breaker arm D is on the lobe of a cam; loosen screw E and adjust screw F until the points are open ·022 in.

Except in very exceptional circumstances it is inadvisable to make any adjustments whatever on any of the other screws G, H, and J. These are provided for convenience in manufacture and to form a method of synchronising the points should excessive wear occur on one of the contact-breaker arms only, or if it has been necessary to replace one arm. Clearly, if the rubbing block on one breaker arm is "higher" than the other, there will be a tendency for the timing of three cylinders to be slightly ahead of the rest; in such circumstances it will be necessary to procure a special synchronising tool from the makers.

To Synchronise the Points.—The tool for this purpose is shown in Fig. 57 (adjustments should be made with the distributor off engine). The contact opening of breaker arm A should be set first (stationary arm), and then the synchronism completed by adjustments to the movable set of points (lever D). Turn the distributor shaft till the rubbing block of the breaker

arm A is on a lobe of the cam. Loosen screw B and turn screw C to get the contact opening, which is from ·018 in. to ·024 in. Tighten B.

Turn shaft again until the rubbing block of breaker arm D is on the lobe of the cam; loosen screw E and turn the screw F until the points open ·018 in. to ·024 in., preferably ·022 in. Tighten E.

The distributor rotates clockwise viewed from the top; place the synchronising tool on shaft with the M side of the spring in the slot in the shaft and turn the shaft in direction of rotation until the graduations of the M side of the tool are near the slot in the rim of the distributor base.

Continue to turn the shaft until the breaker arm A breaks contact, and note the graduation on the tool which aligns with the approaching edge of the slot. Again turn shaft in the same direction, until the same graduation on the N side aligns with the same edge.

Loosen screws G and H and turn screw J until the breaker arm D just breaks contact. Check this by rotating shaft again. Tighten screws G and H. Also check contact opening of the lever D, and if it was set at ·022 in. it should still be within the limits. If outside, reset the point opening and synchronise arms again, confirming the adjustments to the arm D.

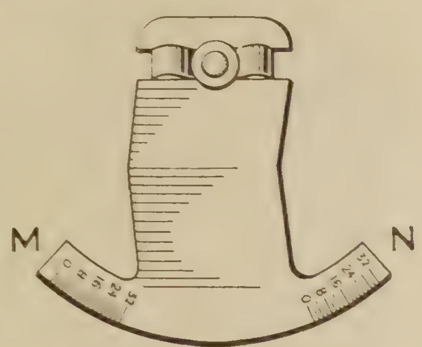


Fig. 57.—The Synchronising Tool.

The graduations on the tool represent engine degrees, and the M side is just 60 cam degrees or 120 engine degrees from like graduations on the N side. The breaker arms must not be out of synchronism more than two engine degrees.

The eye cannot detect the moment the points open, and to get an accurate synchronising adjustment connect an ammeter in the ignition circuit at the distributor terminal. The moment the ammeter drops back to zero, the points are open.

Distributor Lubrication.—The greaser R, Fig. 56, fitted to the side of the distributor shank should be given a half-turn every 500 miles and should be refilled when empty. The felt-pad insert in the top of the distributor shaft underneath the rotor should receive two drops of oil at the same time.

Lightly smear the rubbing faces of the cams with grease once or twice a year. Do not allow any grease or oil to get on to the contact points.

Care of the Simms Coil-ignition System

The principal components of this system are illustrated in Fig. 58. The contact-breaker distributor unit has the condenser mounted outside, on the left side, and spark advance on the right.

The following are the principal points of attention :

(1) *Lubrication.*—All bearings, including the contact-breaker pins, are positively lubricated by wick feed from the automatic advance chamber.

The cam and contact breaker are also positively lubricated by the same means.

The angle of the distributor has no effect upon the lubrication system; an oil flap is provided in a conspicuous position.

As any slackness—due to wear—between the main spindle and its bearing would prevent the cam from rotating accurately and thus cause

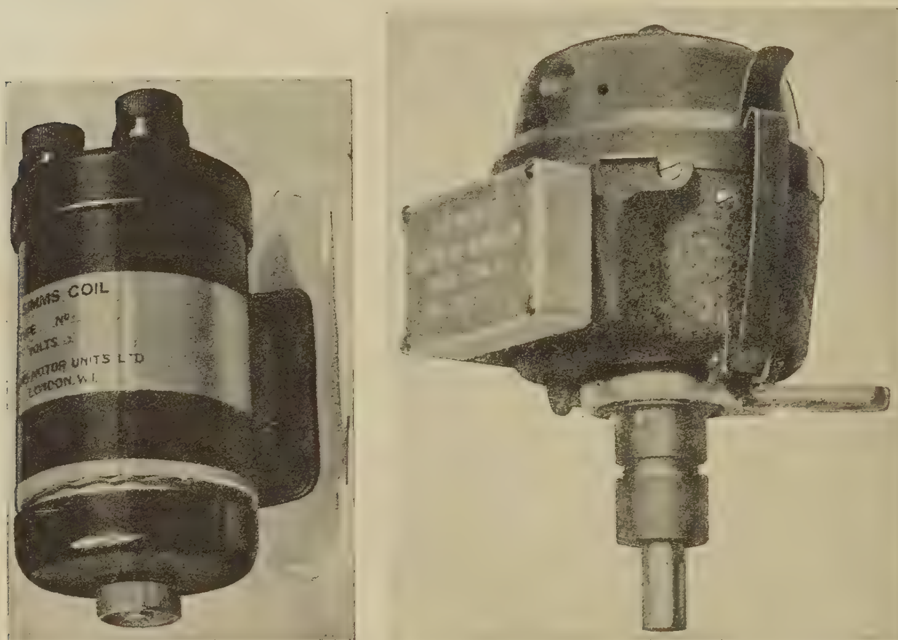


Fig. 58.—The Simms Coil-ignition Components. (Left) The Coil Unit. (Right) The Contact-breaker Unit.

irregular operation of the contact breaker, a ball-bearing is arranged beneath the cam.

(2) *The Contact Breaker.*—This is fitted with L.T.-type springs to give as long a life as possible to the contacts. Two synchronised pairs of contacts, working in parallel, are employed. The points require cleaning and adjustment at long intervals.

(3) *The Condenser.*—This is housed in an aluminium box on the outside of the distributor casing (Fig. 58, right-hand illustration) and connected across the contacts. It is made of mica and tin. No trouble should be experienced with it.

Maintenance of Typical Car Ignition Unit

The maintenance of a typical coil-ignition unit will be described, in some detail, in the case of the Austin 10-h.p. car (and also the light utility commercial vehicle). Fig. 50 should be referred to in this connection.

Diagnosing Cause of Uneven Firing.—The following is the recommended procedure in order to ascertain the cause of uneven firing:

(*a*) Start the engine and set it to run at a fairly fast idling speed.

(*b*) Short circuit each plug in turn by placing a small hammer head or blade of a wooden-handled screwdriver between the terminal and the cylinder head. No difference in the engine performance will be noted when short circuiting the plug in the defective cylinder. Shorting the other plugs will make uneven running more pronounced.

(*c*) Having located the cylinder which is at fault, stop the engine and remove the cable from the terminal of the sparking plug. Restart the engine and, holding the rubber, keep the end of the cable about $\frac{3}{16}$ in. from the cylinder head.

(*d*) If the sparking is strong and regular, the fault probably lies in the sparking plug. Remove the plug, clean, and adjust gap to the correct setting or alternatively fit a replacement plug.

(*e*) If there is no spark or if it is weak and irregular, examine the cable from the sparking plug to the distributor. After a long period of service, the rubber insulation may be cracked or perished, and in this case the cable should be replaced. Finally, examine the moulded distributor cap, wipe the inside and outside with a clean dry cloth, see that the carbon brush moves freely in its holder and examine the moulding closely for sign of breakdown. After long service, it may have become tracked; that is, a conducting path may have formed between two or more of the electrodes or between one of the electrodes and some part of the distributor in contact with the cap. Evidence of a tracked cap is shown by the presence of a thin black line in the places indicated. A replacement moulded distributor cap must be fitted in place of one that has tracked.

Testing the Low-tension Circuit.—(*a*) Spring back the securing clips on the distributor and remove the moulded cap and rotor. If the rotor is a tight fit, it can be carefully levered off with a screw-driver.

(*b*) Check that the contacts are clean and free from pits, burns, oil or grease. Turn engine and check that the contacts are opening and closing correctly and that the clearance when the contacts are fully opened is ·010 in. to ·012 in. Correct as necessary.

(*c*) Switch on the ignition, turn the engine with the starting handle, and observe the ammeter reading, which should rise and fall with the closing and opening of the contacts. If the reading fluctuates in this way, the low-tension circuit is in order.

(*d*) If the ammeter reading remains steady, locate the fault in the low-tension circuit.

(*e*) Another method of testing is to disconnect the cable at the CB

terminal of the coil and at the low-tension terminal of the distributor and connect a test lamp between these terminals. If the lamp lights when the contacts close and goes out when the contacts open, the low-tension circuit is in order.

Locating Fault in Low-tension Circuit.—(*a*) Having determined, by testing as previously described, that the fault lies in the low-tension circuit, switch on the ignition, and turn the engine until the contact-breaker points are fully opened.

(*b*) Refer to the wiring diagram and check the circuit with a voltmeter (0–20 volts) as follows:

Note.—If the circuit is in order, the reading on the voltmeter should be approximately 12.

(*c*) *Battery to ammeter.* Black and yellow cable. Connect voltmeter between ammeter terminal B and a good earthing point. No reading indicates damaged cable or loose connections.

(*d*) *Ammeter.* Connect voltmeter to ammeter terminal A and earth. No reading indicates fault in ammeter, which must be replaced.

(*e*) Ammeter to lighting and ignition switch. Purple and white cable. Connect voltmeter to switch terminal A and earth. No reading indicates damaged cable or loose connections.

(*f*) *Ignition switch.* Connect voltmeter to ignition-switch terminal IG and earth. No reading indicates fault in ignition switch.

(*g*) *Switch-box terminal to ignition-coil terminal SW.* White cable. Connect voltmeter to ignition-coil terminal SW and earth. No reading indicates damaged cable or loose connections.

(*h*) *Ignition coil.* Disconnect the cable from the ignition-coil terminal CB and connect voltmeter to this terminal and earth. No reading indicates fault in primary winding of the coil. If the correct reading is given, replace the original connection to the CB terminal.

(*i*) *Ignition coil to distributor.* White and brown cable. Disconnect the cable from the low-tension terminal on the distributor and connect the voltmeter to the end of this cable and earth. No reading indicates damaged cable or loose connection. If the correct reading is given, replace the connection to the distributor low-tension terminal.

(*j*) *Contact breaker and condenser.* Connect the voltmeter across the contact-breaker points. No reading indicates fault in the condenser.

Austin A40 Ignition-system Maintenance

The Lucas electrical equipment used on the A40 and other modern cars, although identical in principle with that previously described, differs in design and certain details.

A 12-volt, 51 ampere-hour battery is employed in conjunction with a Type Q12 Lucas H.T. coil and Type DKYH4A distributor.

In regard to maintenance of the ignition system the contact-breaker

gap should be set at ·012 in.; a gauge is supplied in the tool kit for this purpose.

The contact-breaker gap is adjusted, when the rocker-arm end is on one of the apexes of the cam, by slackening the two screws which secure the contact plate to the distributor body. The plate is then moved until the gap is set so that the gauge is a sliding fit between the contacts, when the screws are tightened. It is advisable to re-check the gap after tightening these screws.

The cam should be lightly smeared with Mobilgrease No. 2, or, if this is not available, with clean engine oil, every 3,000 miles.

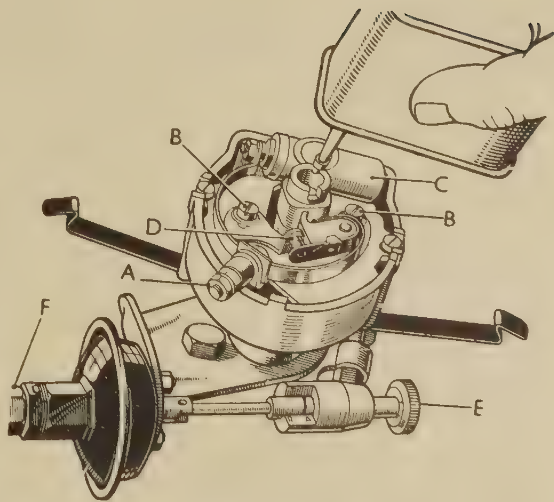


Fig. 59.—Oiling the Camshaft Bearing after Removal of Rotor Arm.

A, Connection from Coil to Contact Breaker. B, Points Adjustment Screws. C, Condenser. D, Contact Points. E, Vacuum Timing Control. F, Vacuum Pipe Union.

The cam bearing is lubricated with machine oil every 3,000 miles. To do this pull off the rotor arm, which will expose a hole (Fig. 59) through which a few drops only of oil can be given. When replacing the rotor arm see that it is pushed well home, otherwise there is a risk of the moulded cap of the distributor becoming burned or tracked. Lubrication should be effected every 3,000 miles.

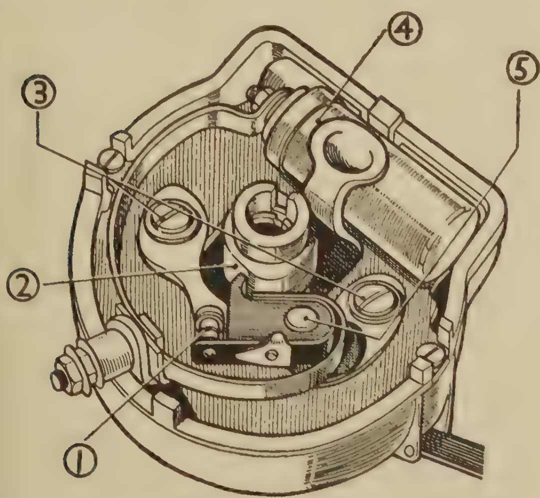


Fig. 60.—The Distributor Head.

1, Contacts. 2, Cam. 3, Screw Securing Contact Plate. 4, Condenser. 5, Contact-breaker Pivot or Bearing.

The automatic timing control is lubricated every 3,000 miles with a few drops of light machine oil through the hole in the contact-breaker base through which the cam passes. It is important to keep oil off the contacts.

The contact-breaker bearing should be lubricated with thin grease or engine oil whenever examination shows this to be necessary.

The contacts should be examined for pitting or unevenness every few thou-

sand miles. To true faulty contacts it is best to remove the contact-breaker lever by slackening the nut on the terminal post and lifting off the spring, which is slotted for this purpose. The lever can then be lifted off. The contacts can be trued with the aid of a fine carborundum slip, as shown in Fig. 61.

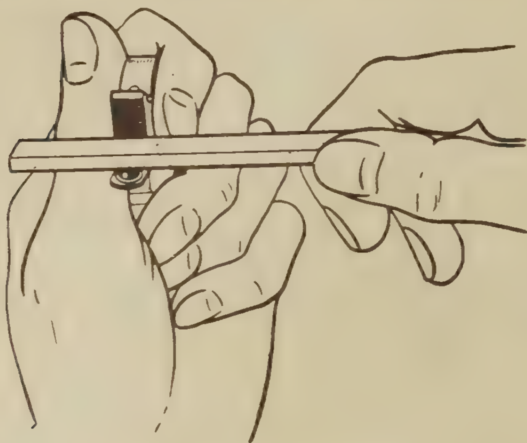


Fig. 61.—Trimming the Contacts.

The distributor casing and cap should be cleaned inside with a soft dry cloth to remove any surface deposits. At the same time see that the carbon brush works freely in its holder.

General Maintenance of Lucas Coil Ignition

The following general information gives all the essential points of maintenance of the various Lucas coil-ignition equipments. Although, considering the relatively long periods and exacting conditions of usage, little attention is required, the user should be thoroughly acquainted with this and also with the proper conditions of operation of the equipment.

Use of the Ignition Control.—On the majority of cars, the ignition is provided with a special timing mechanism which automatically varies the firing-points according to the requirements of the engine.

In addition to the automatic timing control, some cars are fitted with a small-range hand control usually fitted on the steering column. Under normal running conditions, there is no need to make use of the hand control. This is provided for use under special conditions: e.g. when the engine is in need of decarbonising, the experienced driver may find that the engine is assisted by retarding with the manual control.

When the equipment is not fitted with an automatic timing mechanism, retard the ignition control for starting but advance it as soon as the engine is running at speed. Retard when the engine is pulling slowly on full throttle, e.g. when hill climbing, but always keep it as far advanced as possible, consistent with good running. *Always retard when starting, to minimise the possibility of a back-fire.*

After the first 500 miles' running it is usual for the car to be taken to a service station to have various minor adjustments made to the engine. As most of the bedding down of the contact-breaker heel occurs during this period, *the gap between the contacts must be checked* and, if necessary, *reset to give a maximum opening of* ·012 *in.*

Lubrication.—The following parts of the distributor require lubrication:

(1) *Distributor Shaft.*—Add a few drops of thin machine oil through oiler provided about every 1,000 miles (Fig. 62).

In regard to those models of Lucas units that have no lubricator similar to that shown in the lower part of Fig. 62, for the distributor shank and automatic advance mechanism, the position of the oil well provided for this purpose is as shown in Fig. 63.

It should be noted in reference to Fig. 62 that the contact-breaker base is shown removed so as to reveal the automatic advance mechanism below.

(2) *Cam.*—After the first 500 miles, give the cam a smear of engine oil about every 5,000 miles (Fig. 62).

(3) *Cam Bearing.*—About every 3,000 miles, withdraw the moulded rotating arm from the top of the spindle by pulling it off, and add a few drops of thin machine oil (Fig. 62). Do not remove the screw exposed to view, as there is a clearance between the screw and the inner face of the spindle through which the oil passes to lubricate the cam bearing. Take care to refit the arm correctly and to push it on to the shaft as far as possible, otherwise there is a risk of tracking and burning of the moulding.

(4) *Contact-breaker Pivot.*—Every 5,000 miles, place a spot of oil on the pivot on which the contact-breaker rocker arm works.

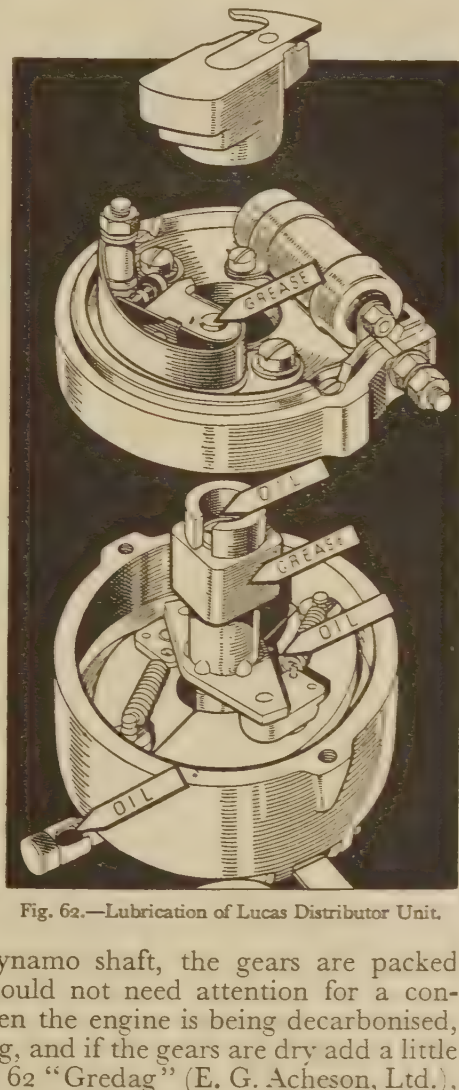


Fig. 62.—Lubrication of Lucas Distributor Unit.

(5) *Distributor Gears.*—When distributors are mounted on the dynamo and are driven from the dynamo shaft, the gears are packed with grease during assembly and should not need attention for a considerable time. Periodically, say when the engine is being decarbonised, move aside the flap on the gear housing, and if the gears are dry add a little high-melting-point grease, such as No. 62 "Gredag" (E. G. Acheson, Ltd.), the grease originally put in the gears at the Lucas works. Care must be taken not to add excess of grease, otherwise it may work its way into the dynamo or distributor.

Cleaning.—Keep the outside of the distributor clean, particularly the spaces between the high-tension terminals. Very occasionally, remove the moulding by spring clips. Wipe the inside clean with a dry cloth, and see that the carbon brush is quite free in its holder. Clean the metal electrodes inside the moulding and also the rotating electrode on the distributor arm; if necessary, use a cloth moistened with a drop of petrol for this.

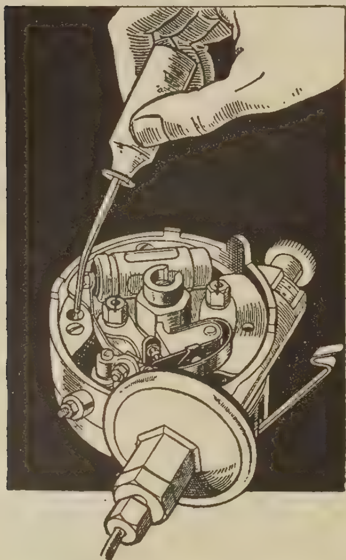


Fig. 63.—Lubricating the Automatic Advance Mechanism.

Next, examine the contact breaker; keep the contacts free from any grease or oil. If they are burned or blackened, clean them with fine carborundum stone, or if this is not available, you can use very fine emery cloth. Finish off with a cloth moistened with petrol, and remove all traces of dirt and metal dust. Misfiring is sometimes caused by dirty contacts.

Checking and Adjusting the Contacts.—After the contacts are reset at the end of 500 miles' running they require only occasional adjustment. The chief cause of variation in the gap is wear of the heel of the contact rocker arm which bears upon the actuating cam. Provided one keeps the cam smeared with lubricant, however, the wear on the wheel will be negligible, and the contact-gap setting should only require adjustment at infrequent intervals.

To check the setting, turn the engine by hand until the contacts are fully opened. Now insert the gauge provided on the ignition screw-driver between the contacts (Fig. 64). The gauge has a thickness of about ·012 in. and it should be a sliding fit between the contacts when the gap is correct. The makers do not advise one to alter the setting unless there is quite an appreciable variation from the gauge. To make the adjustment, keep the engine in the position to give maximum opening of the contacts and slacken the two screws securing the contact plate. Then move the plate until the gap is set to the thickness of the gauge. After making the adjustment, care must be taken to tighten the locking screws.

Fig. 64.—Removing Contact-plate Screws.

Lucas Double-lever Distributors and Contact Breakers.—Some distributors for six-cylinder engines and all those for eight-cylinder engines are of the

double-lever type. Each lever operates for half the number of cylinders, a three- or four-lobe cam being fitted.

The distributor must be inspected and cleaned, and the contacts checked as described previously.

Both gaps must be maintained to the gauge as the contact-breaker levers are synchronised at the works with the gaps accurately set. If the contact gaps are not correct, there will be a tendency for the timing of half the cylinders to be slightly different from the rest.

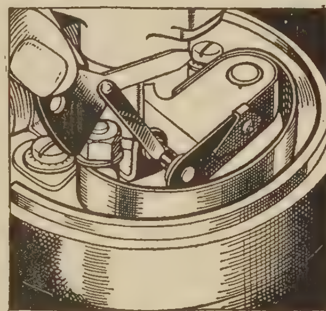


Fig. 65.—Checking Contact-breaker Gap.

To adjust the gaps, slowly turn the engine until one pair of contacts is seen to be fully opened, then slacken the two screws securing the contact plate, and move the plate until the gap is set to the gauge. After the adjustment, tighten the screws and proceed with the adjustment of the other gap in the same way.

Renewing the H.T. Cable.—The H.T. cables are those connecting the coil to the distributor and the distributor to the sparking plugs. When these cables show signs of perishing or cracking, they must be replaced by 7-mm. rubber-covered ignition cable.

The methods of fitting H.T. cable to the distributor and coil vary with

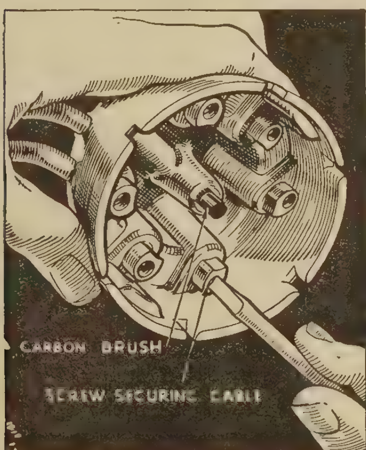


Fig. 66.—Making H.T. Cable Connection.

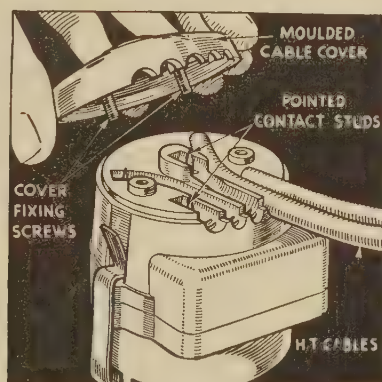


Fig. 67.—Showing Moulded Cover over H.T. Cable Connections.

different units. This is the method of fixing employed on coils and on distributors in which the leads are taken from the unit vertically. The method of connecting the cable is to thread the knurled moulded nut over the lead, bare the end of the cable for about $\frac{1}{2}$ in., thread the wire

COIL-IGNITION TROUBLES AND REMEDIES

Symptoms	*Possible Causes*	*Remedy*
Engine will not fire.	*Battery discharged.* Starter will not turn engine and lamps do not give good light.	Start engine by hand. Battery should be recharged by running car for a long period during daytime. Alternatively recharged from an independent electrical supply.
	Controls not set correctly for starting.	See that ignition is switched on, petrol turned on, and everything is in order for starting.
	Test if coil sparks by removing lead from centre distributor terminal and hold it about ¼ in. away from some metal part of the chassis while engine is turned over. If sparks jump gap regularly, the coil and distributor are functioning correctly.	Examine the sparking plugs, and if these are clean and the gaps correct, the trouble is due to carburettor, petrol supply, etc.
	If the coil does not spark, the trouble may be due to any of the following causes: *Fault in L.T. wiring.* Indicated by (1) No ammeter reading when engine is slowly turned and ignition switch is on, or (2) No spark occurs between the contact points when quickly separated by the fingers when the ignition switch is on.	Examine all cables in ignition circuit and see that all connections are tight. See that battery terminals are secure.
	Contact-breaker points out of adjustment. Turn engine until contacts are fully opened and test gap with gauge.	Adjust gap to gauge.
Engine misfires.	*Dirty or pitted contact points.*	Clean with fine carborundum stone or fine emery cloth and afterwards with a cloth moistened with petrol.
	Contact-breaker points out of adjustment. Turn engine until contacts are fully opened and test gap to gauge.	Adjust gap to gauge.
	Remove each sparking plug in turn, rest it on the cylinder head, and observe whether a spark occurs at the points when the engine is turned. Irregular sparking may be due to dirty plugs or defective H.T. cables. If sparking is regular at all plugs, the trouble is probably due to engine defects.	Clean plugs and adjust the gaps to about ·020 in. Replace any lead if the insulation shows signs of deterioration or cracking. Examine carburettor, petrol supply, etc.

[*J. Lucas Ltd.*]

through the brass washer provided, and bend back the strands. Finally, screw the nut into its respective terminal.

With some distributors, the cables are secured by means of pointed fixing screws. To fit new cables, unscrew the pointed fixing screws on the inside of the moulding and push the cables, which should not be bared, but should be cut off flush to the required length, well home into their respective terminals. The screw securing the centre cable is accessible when the carbon brush is removed.

Now tighten up the screws, which will pierce insulation and make contact with the cable core.

With other types of distributors with horizontal leads, the cables are held in position by a moulded cover which is secured by means of two screws. The cables, which are cut off flush to the required length, are located in recesses in the distributor moulding and are pressed on to pointed terminal studs which pierce the insulation to make good contact with the cable core.

The Coil.—The coil requires no attention whatever beyond keeping its exterior clean, particularly between the terminals, and occasionally checking that the terminal connections are quite tight.

Causes of Misfiring with Coil Ignition

From what has already been written, the causes of most of the ignition troubles with this system will be evident. The following brief summary of the methods which should be employed in tracing the cause of misfiring should, however, prove useful and save time:

(1) Examine the H.T. cables to see if there is a loose or broken connection anywhere. A badly chafed cable may cause misfiring.

(2) Check the sparking plugs for broken insulator, or electrode gap too small or too great—either will cause misfiring.

(3) See that there is no loose connection in the low-tension or battery side. Examine battery connections for corrosion.

(4) The contact-breaker points should be examined for pitting or incorrect gap.

(5) The contact-breaker moving arm should be inspected to see that it is not too tight in its bearing.

(6) Test density of battery, to check whether it is too low.

Timing Coil-ignition Systems

In view of the importance of correct ignition timing upon the performance of a petrol engine, this subject is dealt with in the following considerations at some length. It should be pointed out that, unless an engine is correctly timed under all conditions, not only will the maximum power output be reduced, but the petrol consumption per mile will be

increased; moreover, the acceleration will be affected, and in extreme cases there will be a decided tendency for the engine to " knock " and overheat.

Why Correct Timing is Necessary.—When the charge of petrol vapour and air is compressed within the cylinder to the desired extent, viz. that governed by the compression ratio of the engine, it is ignited by the high-tension spark occurring across the points of the sparking plug and the charge burns very rapidly. Now there must always be a certain interval—or time lag, as it is termed—between the moment at which the spark occurs and that at which the full value of the combustion pressure occurs.

In order to obtain the greatest power output it is generally agreed that the moment of maximum pressure should coincide with that of the top dead-centre position of the piston or slightly past this, as shown in Diagram B, Fig. 68. The point at which the spark occurs is indicated at X on the compression line AX; the pressure rise after ignition is shown by XP, P being the point of maximum pressure; the portion PB is the first part of the expansion line. Referring to Diagram A, it will be seen that if the ignition is timed to occur too early, the maximum pressure will occur at P. Since the piston will still be ascending, the effect of the early ignition will be to cause a counter-pressure on it, over the period represented by distance of P from the top dead-centre line shown. There will be an appreciable loss of power, accompanied by detonation effects, as a rule, due to the ignition occurring too early.

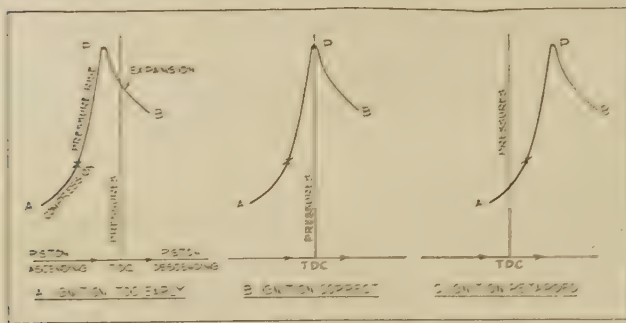


Fig. 68.—Illustrating Theory of Ignition Timing.

If, on the other hand, the ignition is delayed, as shown in Diagram C, the maximum pressure will be developed whilst the piston is actually descending, and if the engine is running at a high speed there will be a loss of pressure between the top dead centre and position corresponding to P. Further, as this pressure occurs late, the full effect of the expansion stroke will not be obtained and there will be higher pressure in the cylinder when the exhaust valve opens.

It should be pointed out that with retarded ignition or with the latter too advanced the actual value of the maximum combustion pressure will be *lower* than for correct ignition timing; for simplicity of explanation all of the maximum pressure values are shown equal in Fig. 68.

In practice, the effect of *too early ignition* is to cause " pinking," accompanied by power loss; and of *too late ignition*, hotter running, loss of power, and heavier fuel consumption.

The Correct Ignition Timing.—Without, for the moment, discussing the means of obtaining the ideal timing result, it may be laid down that the spark should occur at some point before the piston reaches its top dead centre on the compression stroke, such that maximum pressure occurs at top dead centre (Diagram B, Fig. 68).

It is not possible to state explicitly what should be the correct angle of advance, as measured on the crank-pin circle or flywheel rim, since this angle varies in different designs of engines, with different compression ratios, mixture strengths and grades of petrol, and according to the degree of carbon deposit, etc.

Generally speaking, the usual ignition advance at maximum engine speed is 30° to 40° for a modern car engine. For high-compression engines it is usually less, for the same maximum speed, than for engines at lower compression. For ultra-high-speed engines the ignition advance may exceed 45°.

Effect of Fuel Used.—It is important for the maintenance engineer to ascertain from the owner or driver of the car whose ignition unit is to be timed the grade of fuel that will be used, since there is an appreciable difference between the settings for the various commercial spirits.

With the cheaper petrols, normally deficient in those constituents used for preventing detonation, a smaller ignition advance must be employed than for doped fuels such as Ethyl-lead petrols, National benzole mixture and for benzole and alcohol fuel mixtures.

When changing over from ordinary commercial to Ethyl petrol the ignition can be advanced by 5° to 10° with improved running, acceleration, and power results.

Effect of Carbon Deposit.—It is well known to motor-vehicle drivers that whereas an engine will run satisfactorily, when new or clean, with full ignition advance, as it becomes carbonised after several thousands of miles' running it will "pink" much more readily on full advance.

This result is due primarily to the increase in compression pressure owing to the layers of carbon on the combustion walls and piston top; in part it is caused by the bad heat-conditioning properties of the carbon.

To remedy this "pinking" trouble in carbonised engines, one can either use a high-octane-value (or doped) fuel or *retard the ignition*, until all pinking ceases when operating under load at full throttle and maximum engine speed.

In either of the two cases mentioned, viz. change in the grade of fuel or carbonisation, the best ignition setting is a matter of trial and error, road-performance tests being made after each setting until the best results are obtained.

Methods of Timing the Ignition.—Although there are exceptions in special types of motor-vehicle engine, as a general rule the ignition is timed so that when the hand or automatic timing control is in its fully retarded position, the spark occurs at the top dead-centre position of the piston on its compression stroke.

In these cases the procedure is as follows, viz. the piston of No. 1 cylinder, i.e. that nearest to the radiator, is set on its top dead centre (compression stroke). Usually, by removing the sparking plug the piston can be seen with the aid of a small electric torch, or felt with a piece of wire. In most modern engines, however, the flywheel has a mark on its rim—generally a line marked "No. 1"—or, in Vauxhall and Bedford engines, a steel ball embedded in the flywheel, which, when brought opposite a fixed mark or pointer on the engine crankcase or bearer bracket, puts No. 1 piston on its top dead centre.

Having set No. 1 piston thus, disconnect the drive to the crankshaft or casing of the ignition unit, and rotate the latter, in its proper working direction, until the rotating high-tension distributor arm is opposite the brass segment of the distributor, to which No. 1 cylinder sparking-plug cable is connected. Finally, move the contact-breaker unit casing gently until the contact-breaker points are about to separate.

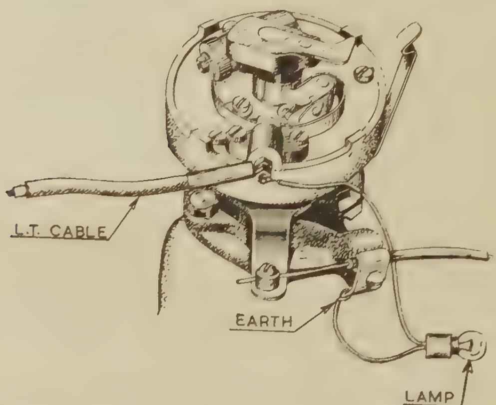


Fig. 69.—Method of Timing the Ignition, using Lamp.

Finding Moment of Contact Points Opening.—In order to ascertain this position accurately, switch on the ignition and note whether the ammeter shows the usual "Discharge" reading, corresponding to the closed position of the contacts. If the contact-breaker casing is slowly moved in the opposite direction to the normal one of the camshaft of ignition unit, the ammeter needle will suddenly flick back to zero; this corresponds to the exact moment of opening of the contacts.

Another precision method of ascertaining when the contacts are about to open is to connect a piece of insulated cable from the low-tension terminal on the contact-breaker casing to one pole of an electric lamp adapter (Fig. 69). Another piece of cable is connected to the other pole and thence goes to any convenient earth connection. Thus the electric lamp—which *must be of the same voltage as the battery*—is connected in shunt between the low-tension terminal of contact breaker and the earth.

When the contact points are together no current can flow through the lamp, but immediately the points begin to separate the current then flows through the lamp and it lights up; it goes "out" again when the contacts close.

The ignition must, of course, be switched on for this test.

The drive from the engine to the ignition camshaft is then connected up, taking care not to disturb either the engine-crankshaft position or that of the ignition camshaft.

In cases where only small adjustments have to be made, it is unnecessary to disconnect the engine drive, but only to loosen the clamping screw or bolt at the base of the ignition unit as shown at (7) in Fig. 70, when the latter can be moved to and fro through an angle of 20° to 30°, as a rule, relatively to the ignition camshaft. The spark-advance lever in this case is of the manually operated type, whilst in addition there is a centrifugally controlled automatic advance. In order to alter the ignition timing in this instance, the advance lever is unclamped on the ignition-unit casing and the latter rotated relatively to it; the advance-lever clamp screw is then tightened securely.

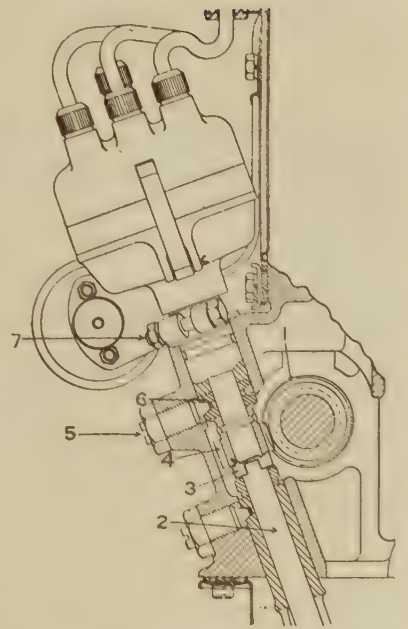


Fig. 70.—A Vauxhall Distributor Unit and its Drive.

1, Cam Gear. 2, Oil-pump Spindle. 3, Oil-pump Driving Jaws. 4, Distributor Gear. 5, Grub Screw. 6, Thrust Washer. 7, Advance and Retard Clamp Bolt.

Timing Austin Engine

The Austin 10-h.p. *engine ignition timing* is as follows. Set the piston of No. 1 cylinder on its top centre (compression stroke). This is effected by means of the flywheel mark (Fig. 71). Then move the flywheel back by a distance of $1\frac{1}{2}$ starter ring teeth (5° to 6° advance) and move up the distributor unit—after slackening the casing holding screw—until the contacts just commence to open. The ignition timing is then correct. The distributor-casing clamping screw must then be tightened.

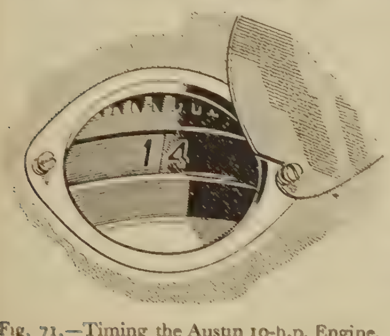


Fig. 71.—Timing the Austin 10-h.p. Engine.

Ignition Timing with Neon Lamp

If a neon lamp is connected in parallel with one of the sparking-plug circuits, then every time a spark occurs at the plug a flash will be given by the neon lamp. Further, if the lamp be in parallel with No. 1 cylinder, i.e. the cylinder at the front or radiator end, and the flywheel rim is marked with a line showing the T.D.C. position of No. 1 cylinder opposite a fixed mark or pointer on the crankcase, then it is possible to arrange for the neon flash to illuminate the T.D.C. mark on the flywheel.

In most cases when the engine is running at idling speeds the spark occurs

on T.D.C. for each cylinder, so that in the case of No. 1 cylinder the neon flash will show the T.D.C. mark exactly opposite the fixed mark on the crankcase if the ignition timing has been set correctly. If, however, the ignition timing is too advanced, the T.D.C. mark will be shown by the flash at some small angular position away from the fixed mark. Similarly, if too much retarded the T.D.C. mark will appear on the other side of the fixed mark.

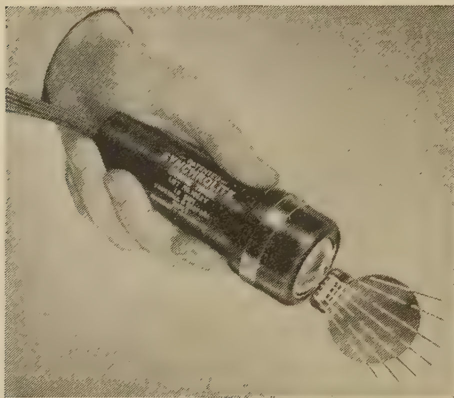


Fig. 72.—The Synchrolite Neon Lamp used for Ignition Timing Purposes.

The connections of the neon lamp tube, a typical commercial example of which is the Synchrolite[1] (Fig. 72), for the Vauxhall Velox ignition timing are shown in Fig. 73. It will be seen that the alligator clips at the ends of the leads of the lamp are connected to the " live " terminal of No. 1 sparking plug and to " earth " respectively. The flywheel rims of the Vauxhall engines have steel balls embedded to show the T.D.C. positions of No. 1 cylinder (Fig. 74). These brightly polished balls stand out clearly in the neon lamp flashes.

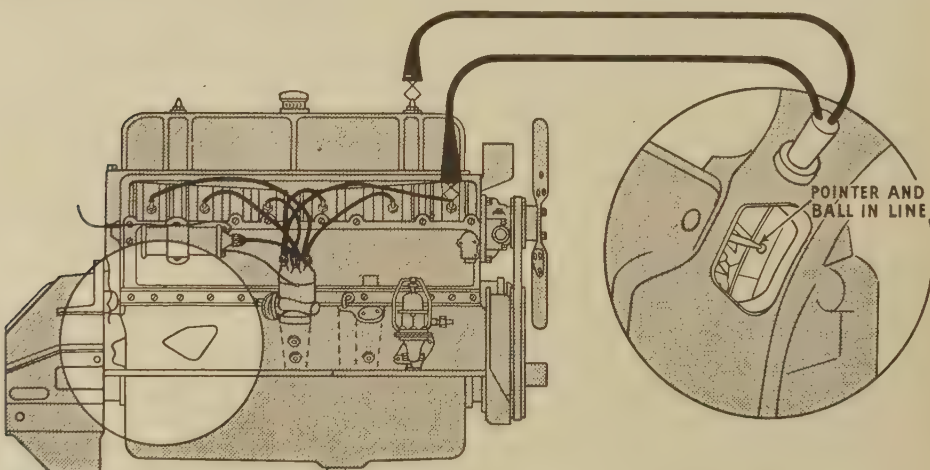


Fig. 73.—Method of Timing the Vauxhall Engines by Neon Light Flashes.

To time the ignition correctly the distributor clamp should be loosened and turned in the appropriate direction until the steel ball, as seen by *the neon flash*, *appears directly opposite the fixed pointer* when the engine is run at

[1] Runbaken Electrical Products Ltd., Manchester.

idling speed. If the ignition is shown to be *too much retarded* the distributor must be turned in *the clockwise direction* to bring the ball opposite the pointer. The timing can, however, be advanced when higher octane fuels are used, by means of an independent octane selector control knob on the base of the distributor.

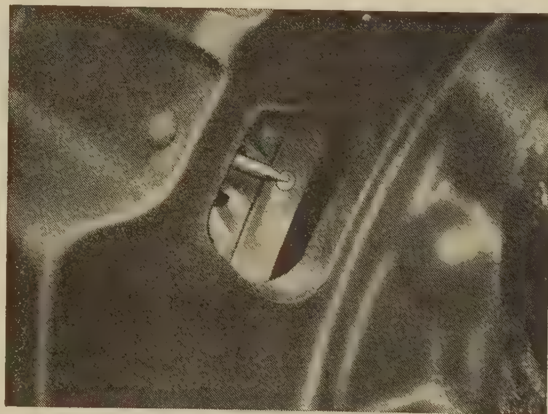


Fig. 74.—The Steel Ball and Pointer (Vauxhall).

The exact point of opening of the contacts in the contact-breaker unit can be ascertained by connecting a test lamp from the live side of the contact-breaker to earth. This is done in the Vauxhall and Bedford engines with a pair of leads and spring clips, as shown in Fig. 75. The complete contact-breaker unit can be removed by unscrewing the locknut on the locating screw and unscrewing the latter; the unit (Fig. 76) can then be lifted out. The distributor casing clamping bolt and nut can be seen just above this locknut.

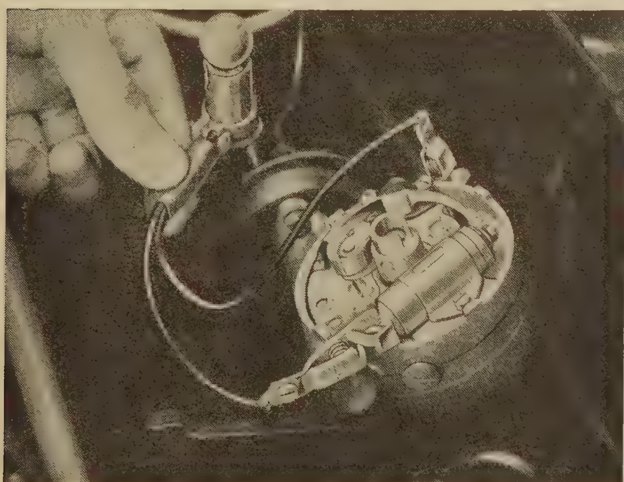


Fig. 75.—Test Lamp for Ignition-timing Check (Bedford).

Timing the Austin A40 Ignition

For timing purposes the flywheel is marked in exactly the same way as that shown in Fig. 71.

In order to time the ignition correctly, remove the sparking plugs except that of No. 1 cylinder. Then set the piston of No. 1 cylinder on its top dead centre (compression stroke).

Next remove distributor cover and slacken the pinch bolt on the distributor-unit clamp. Then turn the distributor casing until the contact-breaker points begin to open, with the rotor-arm brass piece opposite the contact to which the cable from No. 1 plug is con-

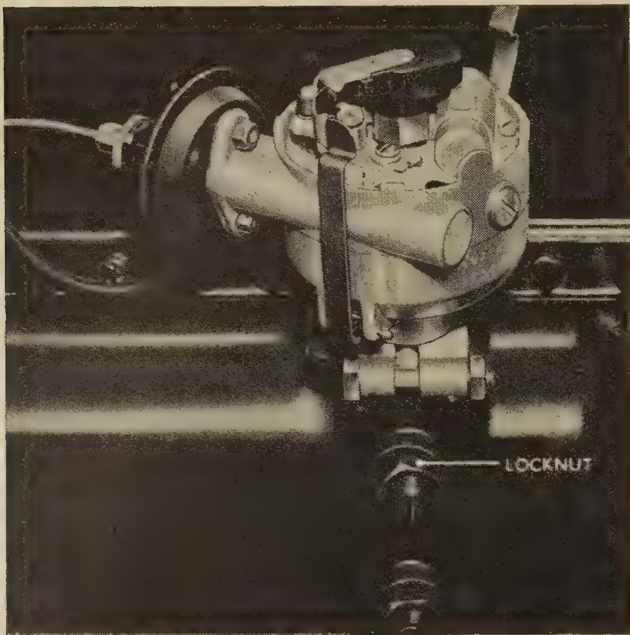


Fig. 76.—The Contact-breaker Unit Locating Screw and its Locknut (Bedford).

nected. The pinch bolt should then be tightened and the adjustment rechecked.

To overcome any possible slackness in the timing chain, the engine should be hand-cranked to bring the piston to its top dead centre position, but the flywheel should not be rotated backwards.

Finer timing adjustments can be obtained under road conditions by means of the micrometer adjustment, shown at E in Fig. 77. This adjustment should be set at zero before the ignition is timed, as described previously. It should only be altered if a different grade of fuel is used, or should the engine show signs of "pinking," as when there is appreciable carbon deposit in the combustion chamber.

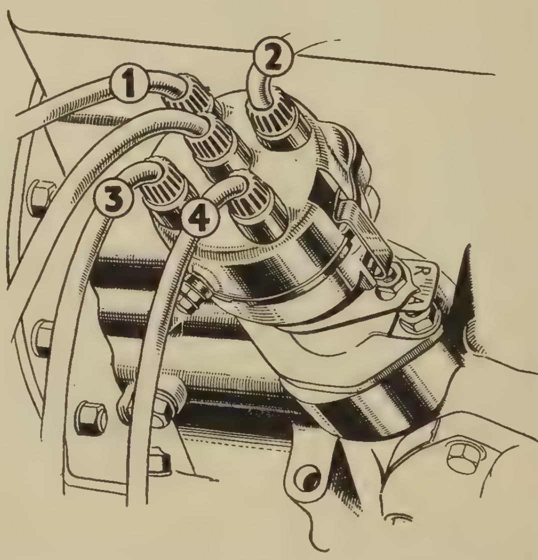


Fig. 77.—The Ignition-timing Adjuster, near the Advance (A) and Retard (R) scale on the Standard Vanguard Engine.

Timing Automatic Control Units

With coil-ignition units having automatic advance and retard mechanism the complete distributor and contact-breaker unit must be accurately located relatively to the engine crankshaft so that what one may term the "zero" position of the unit is correct. Although the automatic advance mechanism gives a good average control of the

ignition timing to suit the range of engine speeds, it must not be concluded that it is the ideal arrangement, for circumstances occasionally arise in the operation of a motor vehicle when an independent or over-riding timing control becomes necessary for the best results.

In certain designs of car the manufacturers have fitted hand control to ignition units having automatic advance mechanisms, so that, in effect, the "zero" positions of the units can be adjusted to obtain the best running results on the road.

In the ordinary distributor and contact-breaker unit having automatic advance control of the centrifugal-action type, this unit is usually located by means of the timing lever. The timing can be adjusted by loosening the clamping screw on the clip and turning the distributor housing in the required direction. The contact-breaker heel is thus moved round the cam, and so the positions of firing are altered.

Before removing the distributor from the engine for any reason, it is advisable to mark the distributor housing and lever so that it can be replaced in the same position and so avoid retiming.

Where detail instructions are not available, the following general procedure for timing or checking the timing can be followed:

(1) Turn the engine over until No. 1 piston is at the top of its compression stroke (that is, on top dead centre). On most engines this position is indicated by a mark on the flywheel.

(2) About half retard the over-riding ignition control (when fitted).

(3) With the engine and the control set in the above positions, the timing is correct if the contacts are just commencing to separate and the metal electrode on the rotating distributor arm is pointing to the insert in the moulding connected to plug No. 1. If necessary, slacken the clamping screw on the timing lever, and turn the distributor housing until this position is found. After setting the distributor, tighten the clamping clip.

See that the plugs are connected to the distributor in sequence according to the firing order of the engine.

(4) If, on running the engine, the firing is found to be slightly too early or too late, this may be corrected by again slackening the clamping screw and turning the distributor a fraction in the required direction, afterwards tightening the clamping clip.

Timing Hillman Minx Engine

The crankshaft pulley is marked with a notch, which registers with a pointer on the timing cover to indicate the top dead centre (T.D.C.) of No. 1 cylinder. The correct position for timing is for the contacts to begin to open when the mark on the pulley is ·3 in. before the pointer, as shown

in Fig. 78. To advance or retard the ignition the clamp screw shown in Fig. 79 should be loosened, when the distributor unit can be adjusted for ignition-timing purposes.

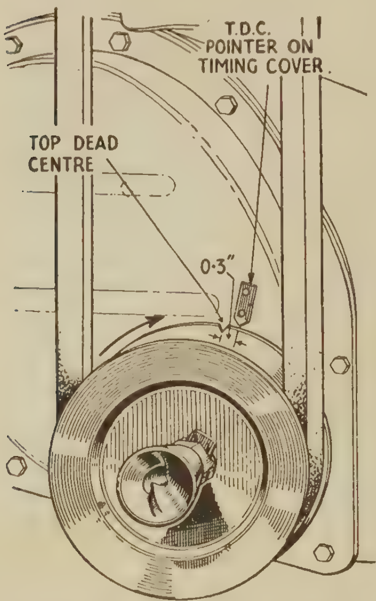


Fig. 78.—Timing Mark on Hillman Minx Engine.

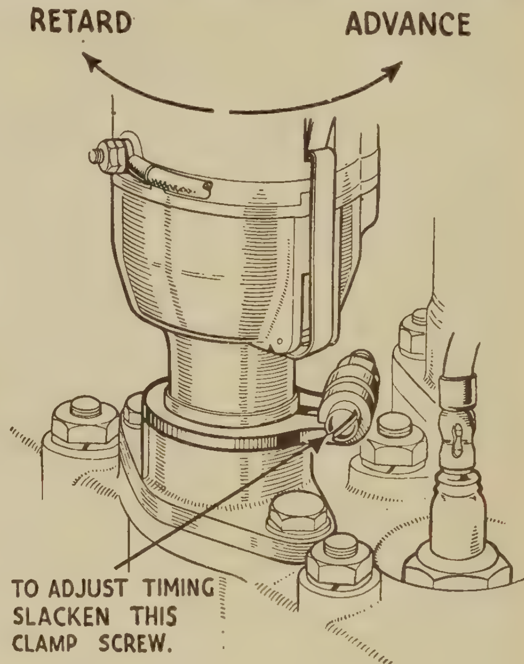


Fig. 79.—Timing the Hillman Minx Engine.

Timing Micromatic-control Distributor Units

In order to obtain very fine timing of the ignition to the engine and to allow for altered engine conditions, e.g. state of carbonisation of engine, change of fuel, etc., a micrometer adjustment is provided on some distributors which allows fine adjustments to be made simply by the movement of a knurled knob. With some cars this adjustment can be made by means of a knob fitted in the dash. Fig. 80 shows a typical micromatic control; this illustration shows also the items of lubrication attention.

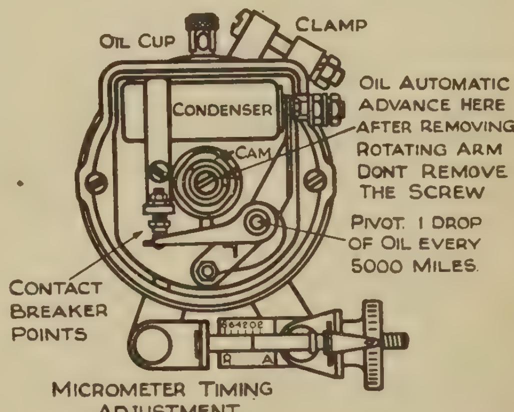


Fig. 80.—The Micromatic Timing Device.

With a clean engine, and using first-grade fuel, the micro-

meter scale should be set at zero before timing, as described in the preceding section.

The final setting can be made by use of the micrometer adjustment after running the engine. If the firing is found to be slightly too early or too late, adjust the knurled knob until the best engine performance is obtained. The adjustment should not be altered by more than one distributor degree at a time (one division on the scale is equivalent to two distributor degrees).

Vacuum Control of Ignition Timing

The centrifugal type of ignition-advance device depends upon the speed of rotation of the engine for its operation; thus, as the engine speed increases, the centrifugal device advances the ignition. It is a well-known fact, however, that at any given engine speed the engine requires more ignition advance when operating at part than at full throttle, so that to obtain the maximum performance an additional ignition-timing control must be fitted. One method of obtaining the desired result is to employ the suction effect which exists in the inlet manifold to operate the ignition timing. The degree of suction depends upon the amount of the throttle opening, so that at light loads a higher vacuum exists than at full loads.

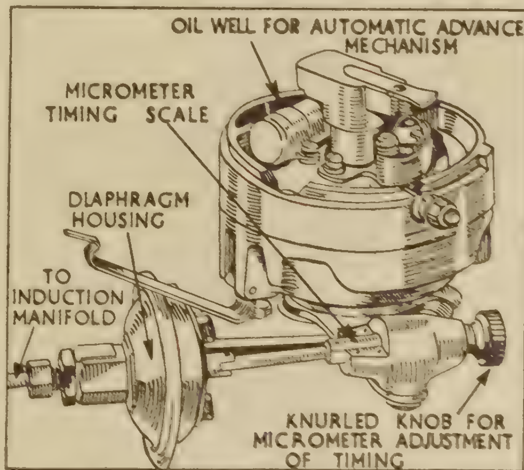


Fig. 81.—Lucas Distributor with Vacuum Control.

The usual form of vacuum control consists of a metal cylinder having a flexible fabric diaphragm, one side of which is connected to the inlet manifold, the other being open to the atmosphere. The movement of the diaphragm is then arranged to rotate the distributor head so as to give an additional control to the centrifugal device usually fitted. The Lucas distributors fitted with this combination vacuum and centrifugal control are shown in Figs. 59 and 81. These have, in addition, a micrometer screw and knob for making fine adjustments of the ignition timing.

The Delco-Remy Ignition System

This well-known system is based upon the same general principles of coil ignition employed in other systems, but differs in design and certain

other details. It is therefore unnecessary to describe the operation, but rather to consider one or two special features and then the maintenance of this system.

The contact breaker and distributor of one model Delco-Remy system is shown in Fig. 82 for explanatory purposes; the more recent models, whilst identical in principle, differ in external and internal lay-out.

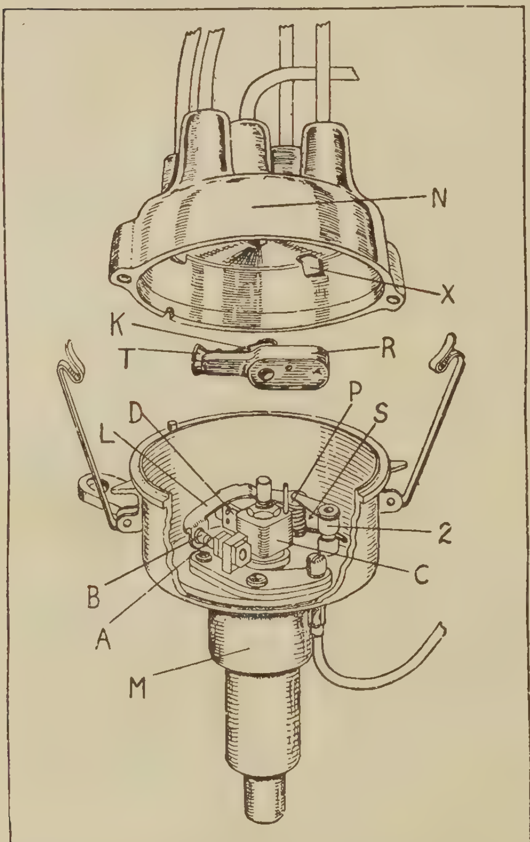


Fig. 82.—The Delco-Remy Contact-breaker and Distributor Unit.

A and B, Contacts. C, Cam. D, Contact-breaker Lever Pad. K, Spring on Top of Rotor Arm. L, Contact-breaker Lever. M, Outer Casing. N, Distributor Cap or Cover. P, Contact-breaker Lever Pivot. R, Rotor Arm. S, Contact-breaker Lever Return Spring. T, Metal Tongue on Rotor. X, Metal Contact to which Sparking-plug Cable is connected. (2). Contact-breaker Retaining Spring.

Automatic Ignition Advance.—The ignition unit incorporates both centrifugal and vacuum ignition advance and retard controls. The former consists of two weights (Fig. 84) which throw out at higher speeds against spring tension to advance the breaker cam with increased engine speed. This advances the timing of the spark in accordance with engine speed. The correct centrifugal spark advance for a particular engine is determined by operating that engine at wide-open throttle and varying the spark advance at each speed until the advance is found which gives maximum power. Centrifugal advance parts, such as the weights, centrifugal cam and springs, are then selected to provide this advance.

Under part-throttle operation there is a vacuum in the intake manifold and consequently the charge taken into the cylinder is not so highly compressed. With this condition an additional spark advance will increase fuel economy. Consequently, on many applications where part-throttle operation predominates a vacuum-advance mechanism is used to secure this additional advance. The vacuum mechanism consists of a spring-loaded diaphragm connected through linkage to the distributor. The spring-loaded side of the diaphragm is air tight and is connected through

a vacuum passage to an opening in the carburettor. This opening is on the atmospheric side of the throttle valve when the throttle is in the idling position. There is consequently no vacuum advance. When the throttle is opened, it swings past the opening of the vacuum passage. The intake

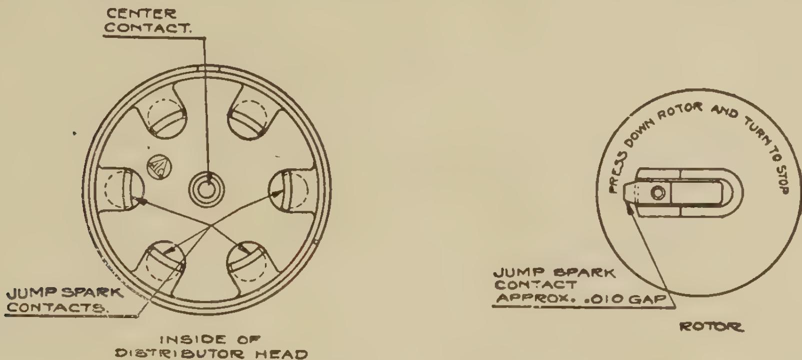


Fig. 83.—A Six-cylinder Jump-spark Distributor.

manifold vacuum then moves the diaphragm and the distributor is rotated in its mounting. This produces a spark advance based on intake manifold vacuum. In addition to the type application which causes the complete distributor to be rotated for vacuum advance, there is another type where the breaker plate is supported on bearings and linked to the vacuum-advance diaphragm so that the breaker plate alone is rotated for vacuum advance. The total advance obtained is the result of centrifugal advance plus the vacuum advance. For example, in Fig. 85 the centrifugal advance mechanism provides 15° advance at 40 m.p.h. Under part-throttle operation the vacuum mechanism may provide up to 15° additional advance for a total of 30° advance. With wide-open throttle, however, this vacuum advance would not be obtained; all advance would then be based on the operation of the centrifugal mechanism.

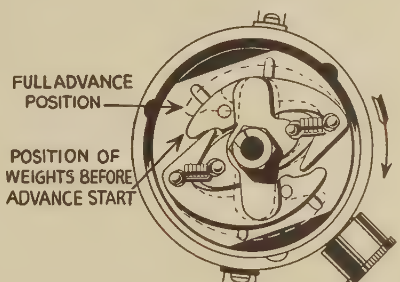


Fig. 84.—Delco-Remy Automatic Ignition Advance.

A typical distributor unit of the many models available has the following *automatic advance values:*

Cam angle, 35°. At 600 engine r.p.m. the start advance is 2° (crankshaft angle). At 1,200 r.p.m. the intermediate advance is 9°, and at 2,200 r.p.m. the maximum advance is 17°.

Maintenance Notes.—*Contact-breaker Points.*—These may be cleaned with a contact file or stone supplied for the purpose, but *emery cloth should never be used.* The contacts after much service will not appear smooth and bright,

but this is not necessarily an indication that they are not functioning satisfactorily, since they may be making contact over a greater area than new points.

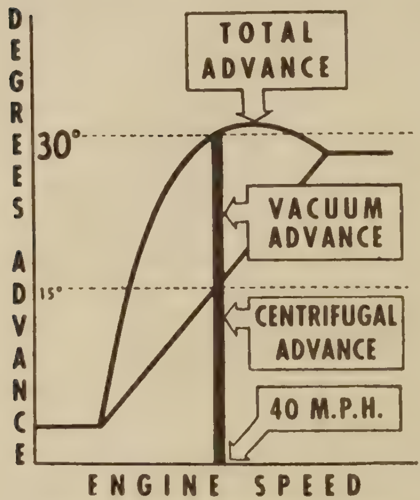


Fig. 85.—Delco-Remy Ignition Advance.

Contact-point opening, on or off the vehicle, may be checked with a special type of dial indicator (Fig. 86), a device which measures accurately the movement of the movable point. A feeler gauge cannot successfully be used to accurately check the contact-point opening of used contacts, since it measures from high point to high point and not the true contact-point opening. A feeler gauge may be used, however, in an emergency, but it must be remembered that the accurate settings required for best operation of modern engines cannot be made with a feeler gauge.

Another method of measuring the contact-breaker gap is by use of a cam or contact angle meter. This measures the number of degrees the cam rotates between the instant the points close and the instant they open, as explained on page 49. This angle increases as the point opening is lowered and decreases as it is increased. The cam angle is usually 35°, but may vary from 33° to 38° for Delco-Remy distributors of different types.

Contact-point opening or cam angle may be adjusted by loosening the locking screw holding the stationary contact support and turning the eccentric. After adjustment is made, tighten the locking screw and recheck the setting. The point opening is ·018 to ·024 in. on all distributors.

Contact-point pressure is checked by using a spring gauge hooked to the lever arm and the pull exerted in the direction indicated. For the two types of arms the tension should be as given by the manufacturers. Adjustment may be made by bending the breaker-lever spring to increase or decrease the tension as required.

Note.—New breaker-lever springs may have too much tension; therefore, after installing new points always check the point pressure and adjust it if required.

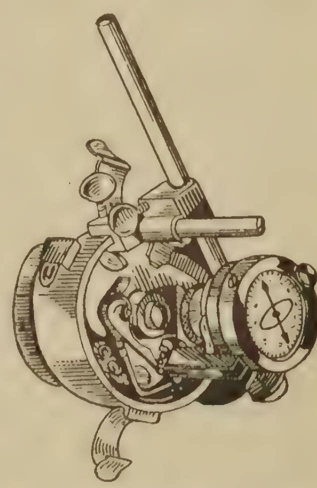


Fig. 86.—Dial Method of Setting Contact-breaker Opening.

The centrifugal- and vacuum-advance mechanisms may be tested on a synchroscope or distributor tester, which checks their operation at the various dis-

tributor speeds and vacuum conditions the unit will encounter in operation. If the centrifugal-advance mechanism does not provide the proper advance, it should be disassembled, the parts cleaned and oiled lightly, and reassembled. A new vacuum-advance mechanism should be installed if the original unit is not functioning properly, since repair of this unit is not usually advisable.

Timing is accomplished by several methods, depending upon the provision made for timing by the engine manufacturer and the equipment available. Most applications have some marking on the flywheel or dynamic balancer which aligns with a pointer on the housing when number one cylinder is ready to fire. Other applications require the use of a piston position gauge. Whatever the method, timing is accomplished by loosening the distributor clamp and rotating the distributor in its mounting so the contact points will open with the proper relation to the position of the pistons in the cylinders.

The ignition coil requires a special testing instrument in order to determine its condition accurately. Two types of instuments are in general use —the spark gap or neon-tube method, and the high-frequency method wherein the condition of the coil is measured on a meter. There is always the possibility of error in the spark-gap method, but if properly handled it will disclose a definitely bad coil in comparison with a known good coil of the same model number operated under identical conditions. The high-frequency method (using a radio circuit-type tester), on the other hand, eliminates the human element in testing, and will accurately determine the actual condition of the ignition coil and will detect such defects as shorted primary or secondary turns, high-voltage breakdown in the secondary, high resistance in the primary, as well as an open-circuited primary or secondary.

Routine or Periodic Attention (Delco-Remy System)

It is recommended that a systematic procedure of checking the units in the ignition system be followed. In addition, the distributor should be lubricated periodically.

30 Days or 1,000 Miles.—Lubricate the distributor by turning the grease cup down one turn. Keep grease cup filled with medium cup grease. On the type unit with hinge cup oilers, add 8 to 10 drops of light engine oil every 1,000 miles. Lubricate high-pressure grease fittings every 1,000 miles.

Remove the cap and check cap and rotor for chips, cracks, or burned paths which would allow high-tension leakage. Wipe out cap with a dry, soft cloth. Check high-tension wiring for frayed or damaged insulation and poor connections at cap, coil, or plugs. Inspect contact points. The contact-point opening may be checked with the distributor on the vehicle by using either a dial indicator or a contact angle meter. If the points need cleaning, this may be done on the vehicle. Use a clean, fine-cut

contact file or stone. Never use emery cloth or sandpaper, since particles of sand or emery may embed in the point surfaces, where they would cause arcing and burning. If the points need replacement, remove the distributor from the vehicle, as this job can be done more easily on the bench. The position of the distributor and rotor should be noted before removing the distributor so that the distributor can be replaced in approximately the same position. Only a small adjustment will then be required to complete the timing.

Check the vacuum-advance mechanism on the type distributor which rotates the complete distributor for vacuum advance by rotating the distributor in its mounting. It should rotate freely, and the vacuum-advance spring should bring it back to its original position when released without sticking. On the type distributor where the breaker plate is supported on balls for vacuum advance, rotate the breaker plate. Check the centrifugal-advance mechanism by rotating the breaker cam in the direction of its normal rotation. It should rotate freely, and the advance springs should bring it back to its original position when released. These checks give a quick indication of the condition of the advances; a complete check requires the use of a synchroscope or distributor tester.

6 Months or 6,000 Miles.—In addition to the lubrication supplied to the distributor every 30 days or 1,000 miles, at the 6-month or 6,000-mile period the breaker cam should be lubricated with a trace of petrolatum and a few drops of light engine oil should be added to the felt wick under the rotor.

Where the breaker plate is supported on balls, put a drop or two of light engine oil on each ball. Avoid excessive lubrication.

In order to eliminate the effects of the normal wear which takes place, it is advisable to remove the distributor, disassemble it, clean all parts, replace worn parts, and reassemble the unit. While this can be done every 6 months or 6,000 miles, it may be necessary only seasonally, as every autumn.

If testing equipment is available, the distributor may then be checked on a synchroscope, which will test the vacuum and centrifugal advances and the contact or cam angle. Test the condenser and coil on the proper testing instruments.

Quick Methods for Checking Ignition Troubles (Delco-Remy)

In order to determine the actual cause of ignition trouble, a definite system of checking should be used. The following must be considered merely as quick checks to get an approximate idea of the location of trouble. This may be an aid in temporarily correcting the trouble in an emergency so the vehicle can be brought in for a more complete check. A complete analysis of the ignition system requires accurate testing instruments. Two separate sets of quick checks may be made, according to whether the engine will or will not operate.

Engine Will Not Run.—If the cranking motor cranks the engine at normal cranking speed but the engine will not start, remove lead from one spark plug and hold lead terminal about $\frac{3}{16}$-in. from engine block. If a good spark occurs while engine is being cranked, the ignition primary and secondary circuits are probably correct, and the trouble is likely arising from a wrong timing condition or from some other cause in the engine, such as carburation, etc.

If a spark does not occur, check the dash ammeter reading while cranking:

(*a*) If there is a small reading which shows some fluctuation while cranking, the primary is probably correct. The secondary is not delivering a spark due to loss of energy in secondary circuit or the condenser being defective.

(*b*) If there is no reading, the primary circuit is open, due to loose connections, defective wiring or switch, distributor points not making contact, or an open-coil primary. Visual inspection of the points and the use of a test light will locate the source of this trouble.

(*c*) If the ammeter shows a reading of several amperes and the needle does not fluctuate while cranking, either the contact points are out of adjustment so they are not breaking, or the coil primary circuit is grounded, in the coil or externally.

If the cranking motor cranks the engine slowly or not at all, then the trouble probably lies either in the battery, cables or connections, or in the cranking motor.

Engine Runs but will not Perform Satisfactorily.—This condition is probably the most difficult of all to analyse, because of the many other factors in addition to ignition which influence engine performance. While the usual recourse is a complete engine tune-up, which includes ignition, some indication of the cause of the trouble, if due to ignition, may be deduced from the type of trouble experienced:

(*a*) Overheating may be due to wrong ignition timing—usually to too much retard.

(*b*) Detonation or " pinking " other than that due to certain poorer grades of fuel may be caused by wrong ignition timing, improper operation of the centrifugal, or vacuum advance, points out of adjustment, worn distributor bearing or shaft, bent shaft, or plugs of wrong heat range.

(*c*) With missing, hard starting, or loss of power a complete check of the ignition system should be made, since these conditions may be caused by anything from a low battery to defective spark plugs.

Note.—The above complaints (*a*), (*b*), and (*c*) may arise from other conditions in the engine besides ignition, but only the probable ignition items are here considered.

The Autolite Coil-ignition Unit

The Autolite ignition apparatus is fitted to many modern American cars, a typical instance being that of the Kaiser-Frazer cars, which employ both the centrifugal and vacuum automatic-ignition advance.

The principle of the vacuum-control method used is illustrated in Fig. 87, which shows the vacuum-pipe connection to the inlet (intake) manifold and, at its other end, to the vacuum chamber. When a partial vacuum occurs, as at normal running conditions, the diaphragm, seen at D in Fig. 87, is pulled downwards against the pressure of the compression spring S, and it then pulls the levers L attached to the contact-breaker plate downwards, thus advancing the ignition. *When the engine is idling* there is practically no vacuum in the inlet manifold, so that the vacuum control does not operate. Similarly, at wide-open throttle conditions there is insufficient vacuum to cause the diaphragm to move against the spring pressure. It is therefore only under part-load conditions that this control works.

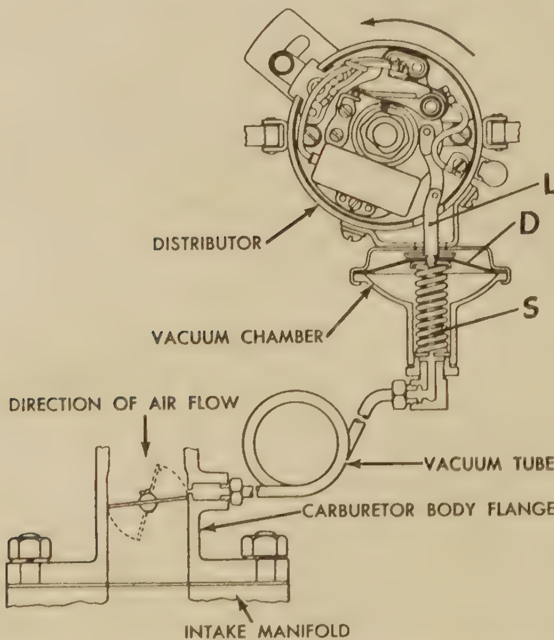


Fig. 87.—The Autolite Vacuum-type Ignition Control System.

Fig. 88 shows the Autolite distributor unit with the cap and rotor arm removed. The various components are easily identified from the lettering and indication arrows. The unit shown is for a six-cylinder engine and corresponds to that illustrated in Fig. 87.

It will be observed that the correct contact-breaker gap is ·020 to ·024 in. and that this gap is adjusted by means of the screw marked "breaker-point adjusting screw."

Quick Method of Checking Automatic Advance

Whilst special test equipment is essential for accurate testing and for taking readings of ignition advance angles, etc., it is possible by simple practical tests to ascertain whether the vacuum and centrifugal devices are operating satisfactorily, although these tests do not give any quantitative results. The methods recommended for the unit shown in Fig. 88 are as follows:

(*a*) **Centrifugal-advance Check.**—With the distributor cap removed, turn the rotor anti-clockwise with the fingers. If the mechanism is free, the governor springs will pull the governor weights back when released, and will also return the cam to the retarded position. Should the mechanism be found sluggish, or if binding occurs, it should be dismantled and examined for the cause.

(*b*) **Vacuum Advance.**—By pushing against the condenser with the fingers, turn the distributor breaker plate clockwise and release it. The vacuum-advance spring should then pull the plate back to the retarded position if the plate turns freely on its bearings.

To make a quick check for *leakage in the diaphragm* disconnect the vacuum pipe from the vacuum-advance unit. Using a flexible hose similar to that used on some windscreen wipers, apply suction with the mouth to test for a vacuum leakage.

The Ford 8-h.p. (Anglia) and 10-h.p. (Prefect) Ignition System

These models employ the 6-volt coil-ignition system. The distributor is mounted accessibly on the top of the cylinder head on the near side of the engine. Fig. 89 shows the distributor unit with the H.T. rotor and the cap, carrying the four brass contacts removed.

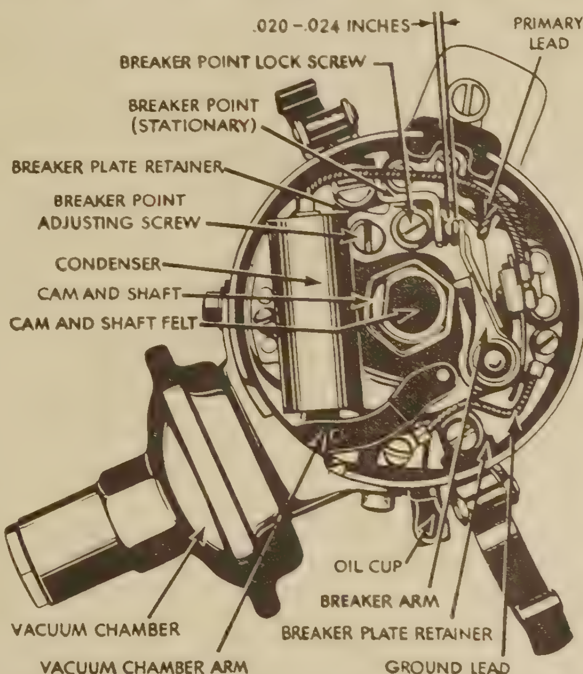


Fig. 88.—The Autolite Contact-breaker Unit (Distributor Cap and Rotor Arm removed).

The ignition timing is automatically retarded for starting by the usual automatic control, using centrifugal governor weights and springs. The contact-breaker unit is shown in Fig. 90. The contact-breaker points are adjusted as follows:

The gap between the breaker points should be set at ·010 to ·012 in., with the fibre block of the breaker arm on the high lobe of the cam. This gap should be checked occasionally to see that the points are clean and properly adjusted.

If the points are worn, pitted, burned, or incorrectly spaced, they should be dressed smooth with an oil-stone. *Do not use a file.* Badly burned or pitted breaker points are usually an indication of condenser trouble or a poor battery connection.

Lift off the distributor cover and rotor, turn the engine over slowly with the starting handle until the breaker arm rests on one of the lobes of the cam with the breaker points fully open.

Loosen the two screws securing the fixed contact-point arm to the base

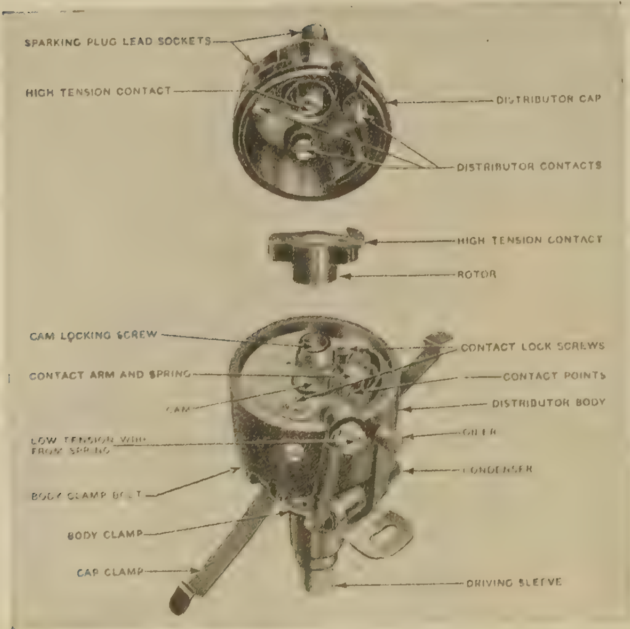


Fig. 89.—The Ford 8-h.p. and 10-h.p. Distributor and Contact-breaker Unit.

plate (Fig. 90), and move the arm until the correct gap of ·010 to ·012 in. is obtained. This gap should be checked by means of a standard thickness gauge.

When correct adjustment is obtained, tighten the two arm-securing screws. After tightening, again check the gap to make sure that the adjustment has not been altered.

Replace the rotor and distributor cover.

Timing the Ignition.—The ignition timing as set by the makers gives the best all-round results. A graduated scale (Figs. 90 and 91) is provided on the distributor securing clamp to enable fine adjustments to be made. The scale is marked " A " for advance and " R " for retard, and is calibrated so that one division is equal to two distributor or four engine degrees. To adjust, slacken the screw passing through the slot alongside the scale and move the distributor body in a clockwise direction looking from the top of the distributor to advance the spark. Be sure that the clamping screw is tightened after making the adjustment. It is important *not to interfere with the body-clamping bolt.*

If *the distributor has been removed* from the engine or has been disturbed in any way, it is important that it is refitted with the index scale in its original position.

To ensure correct timing, screw out the

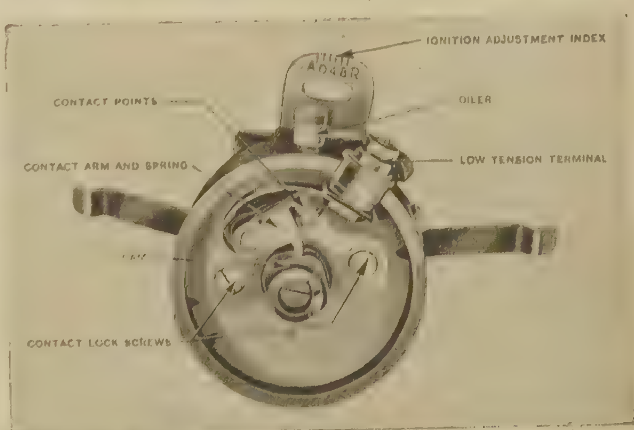


Fig. 90.—The Ford 8-h.p. Contact-breaker Unit.

timing pin located in the cylinder front cover (Fig. 92) and insert the plain end of the pin into the hole from which it has been removed. Then turn the crankshaft slowly with the handle, pressing the timing pin against the camshaft sprocket face. As soon as the pin drops into the timing indentation machined in the sprocket, stop turning and replace the timing pin.

Remove the distributor cap and make sure that the rotor is facing No. 1 cylinder high-tension contact position; check that the offset tongue at the bottom of the distributor shaft will mate correctly with the offset slot in the distributor coupling shaft in the cylinder-block location (Fig. 93).

Fig. 91.—Ignition-timing Adjustment on Ford Engines.

Place the distributor back into position in the engine and secure the body-clamp plate to the cylinder head by means of the screw and lock washer, ensuring at the same time that the zero reading of the scale is set against the index mark on the cylinder head. Slacken off the body-clamp bolt and turn the distributor in a clockwise direction to take up any backlash in the drive, until the contact-breaker points are just about to open. This should occur when the condenser is approximately parallel with the cylinder head.

Lock the distributor body clamp by tightening the clamp bolt. Reset

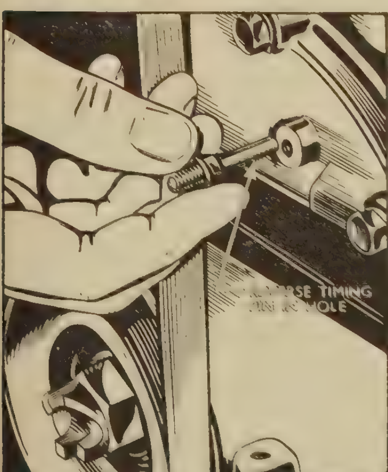


Fig. 92.—The Ford Timing Pin.

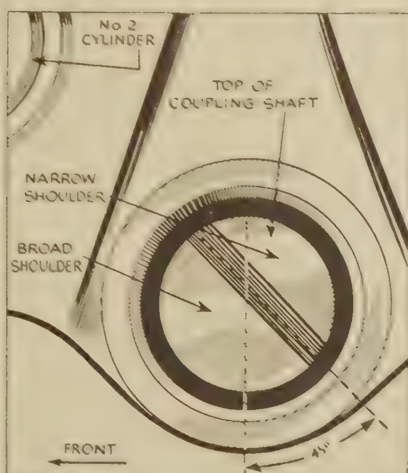


Fig. 93.—Offset Tongue and Slot on Distributor Shaft End.

the index scale to the division between " 0 " and " 4." Tighten the clamp screw.

The ignition timing should now be correct and all adjustments made should be checked

Ford Ignition Troubles and their Remedies

A certain amount of skilled attention is necessary in order to obtain the best results from the ignition system; otherwise poor performance, high fuel consumption, and overheating may result.

The following procedure is recommended for finding faults in the ignition system.

(1) Disconnect the black L.T. wire from coil to distributor at the distributor (see Fig. 89).

(2) Turn ignition switch to " on " position.

(3) Touch disconnected wire to cylinder. If a spark does not occur, check each wire and connection back through the battery to the battery ground, for a break in the circuit.

(4) If a spark occurs when the ignition switch to coil wire is grounded to the cylinder, see that the coil to distributor H.T. (heavy rubber covered) wire is making good contact at both ends. If contact is good, remove the distributor cover and examine the contact points (see Fig. 90).

(5) Check the gap between the sparking-plug points. Clean the plugs and adjust to ·022 in

The Ford V-8 Ignition System

This system is a coil-ignition one using a 6-volt, 80-ampere-hour, 17-plate battery.

The firing order is as follows: 1, 5, 4, 8, 6, 3, 7, 2.

The distributor is located at the front of the engine and is driven directly by the camshaft. The ignition timing is automatically retarded by the centrifugal-governor weight springs for starting. By means of this centrifugal governor the ignition is automatically advanced at increased engine speeds in direct proportion to the speed.

For quick acceleration a slightly retarded spark is required temporarily, and this is achieved by means of *a vacuum brake* consisting of a piston which is pressed against the edge of the governor plate by a spring. A tube leads from the intake manifold, and the suction existing normally there holds the leather-padded piston away from the governor plate. When the throttle is suddenly opened the suction of the piston decreases and the spring presses it against the governor plate, retarding the ignition. When the engine picks up speed the suction again increases in the connecting tube and pulls back the piston, allowing the centrifugal governor to advance the ignition in the normal manner.

The Contact Breaker.—The contact breaker of the Ford V-8, used before the Pilot model, is illustrated in Fig. 94. It will be observed that there are two contact-breaker units which operate in conjunction with an eight-lobe cam. The vacuum-brake piston and cylinder are also shown.

The contact-breaker unit of the Ford V-8 Pilot engine is illustrated in Fig. 95, and in connection with its maintenance the maximum gap, when the fibre heel of the moving arm is on an apex of the cam, should be ·014 to ·016 in. The gap can be adjusted by slackening off the two lock screws on the fixed contact point and adjusting until the gap is correct. Tighten up the lock screws to prevent the gap from altering in service, and re-check the gap. Each pair of contacts should, of course, be treated in the same manner.

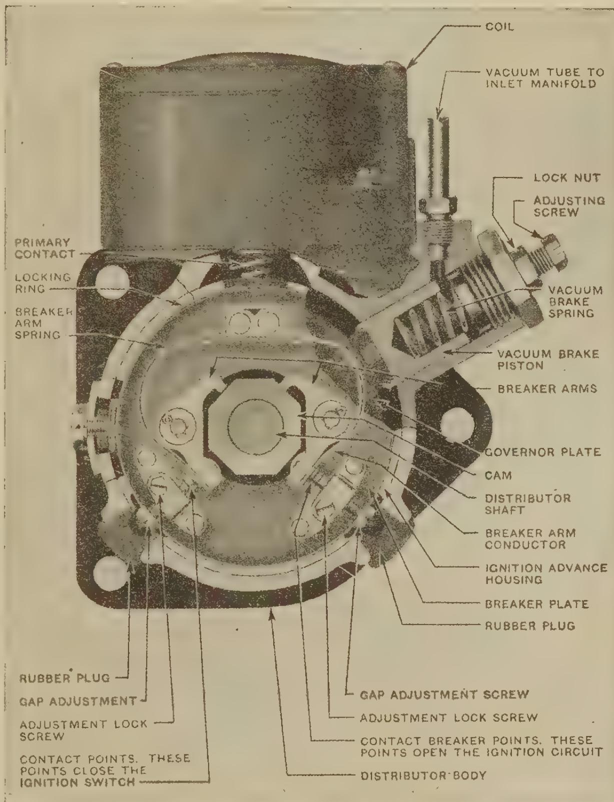


Fig. 94.—The Ford V-8 Contact-breaker Unit.

The Distributor.—If, for any reason, the distributor is removed at any time for checking the contact-breaker point gaps or renewing the contacts, it is essential that it is refitted with the index plate in its original position. This index plate with its securing screw, as well as the vacuum-brake unit, suction pipe, and adjusting screw, is shown in Fig. 95.

Vacuum-brake Adjustment.—The ignition advance can be adjusted to suit the octane value of the fuel by means of the vacuum-brake adjusting screw, shown on the top right-hand side in Fig. 95. The car should be given a road test for acceleration, i.e. for quick acceleration from 12 m.p.h. in top gear. If the engine is found to " pink " under this test, unlock the nut on the brake-adjusting screw and turn the screw about half a turn in *a clockwise direction.* Re-test and readjust until all signs of " pinking " vanish.

Should the engine not "pink" under the test conditions, turn the adjusting screw anti-clockwise until "pinking" just occurs. Then turn the screw slightly backwards, i.e. in a clockwise direction, until "pinking" just vanishes. Finally, tighten the lock-nut and re-check for no "pinking."

Fault Tracing.—The following is the procedure recommended for Ford V-8 cars:

(1) Disconnect the red wire from the coil.

(2) Turn ignition switch to "on" position.

(3) Touch the disconnected wire to the cylinder. If a spark does not occur, check each wire and connection back through the battery to the battery switch for a break in the circuit.

(4) If a spark occurs when the ignition switch to coil wire is "earthed" to the cylinder, remove the distributor side covers and examine the contact-breaker points. If the latter are found to be worn, pitted, burned, or incorrectly spaced, dress them smooth with an oil-stone. Adjust the gap to ·012 to ·014 in. with the fibre breaker arm on the high point of the cam.

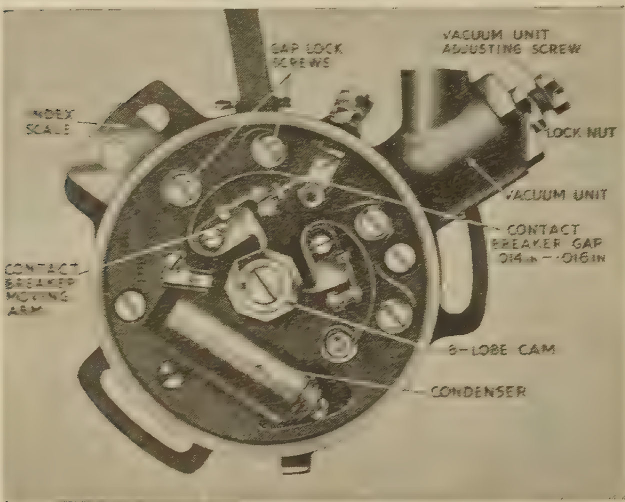


Fig. 95.—The Ford V-8 Contact-breaker Unit.

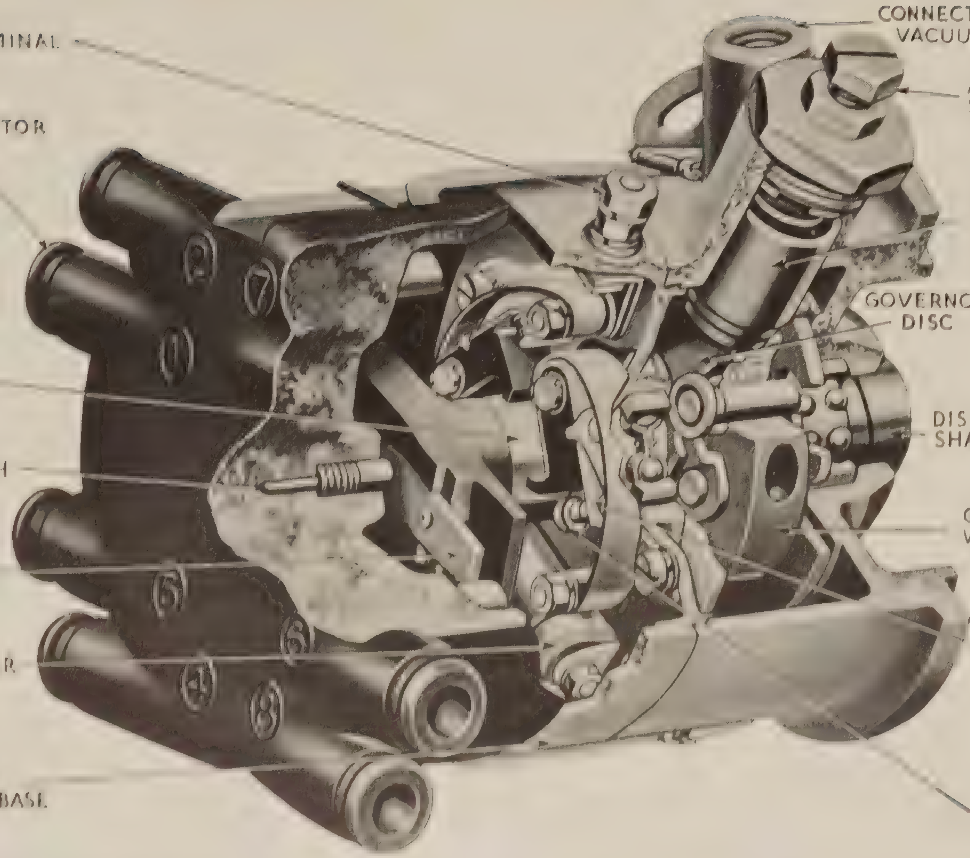
(5) If the trouble has not been corrected, remove the distributor terminal plates and side covers. Switch on the ignition. Earth a wooden-handled screw-driver to the distributor body, holding the end of the screw-driver blade about $\frac{3}{16}$ in. from the metal band round the centre of the rotor.

When the engine is cranked, a spark should occur between the rotor and the screw-driver. If a $\frac{3}{8}$-in. spark occurs regularly, further tests of the primary circuit and the coil are unnecessary.

If a spark of less than $\frac{3}{16}$ in. occurs it is probable that the rotor, condenser, or coil is short-circuited.

If no spark is observed, then the primary circuit is not completed at some point within the distributor.

If a satisfactory spark is obtained at the rotor but *no spark occurs at the plugs*, the sparking-plug wires, terminal plates or distributor side covers are short-circuited, probably owing to the engine having been operated at some time with one of the plug cables disconnected from either the sparking plug or the terminal plate. To isolate the part at fault, while the engine



THE FORD PILOT V 8 CONTACT BREAKER AND DISTRIBUTOR UNIT, SHOWING VACUUM BRAKE IGNITION AND CENTRIFUGAL GOVERNOR ADVANCE MEMBERS.

is cranked hold each sparking-plug cable (plug end) $\frac{3}{16}$ in. away from the cylinder head. Any wire from which the spark bridges this $\frac{3}{16}$-in. gap can be considered satisfactory. Any wires not satisfying this test should have the terminal plates and side covers examined for evidence of leakage before they are condemned.

(6) Check the gap between the sparking-plug points. Clean the plugs and adjust the gaps to correct values or maker's gauge in each case.

A Coil-ignition Tip

A reliable method of starting the engine in cases where the battery is completely exhausted is to loan, or otherwise procure, another battery and to connect this in parallel with the exhausted battery, positive pole to positive pole. If the engine be cranked around by hand with the switch on, it can readily be started in this way. As soon as it commences to run regularly the auxiliary battery should be removed, when the dynamo will

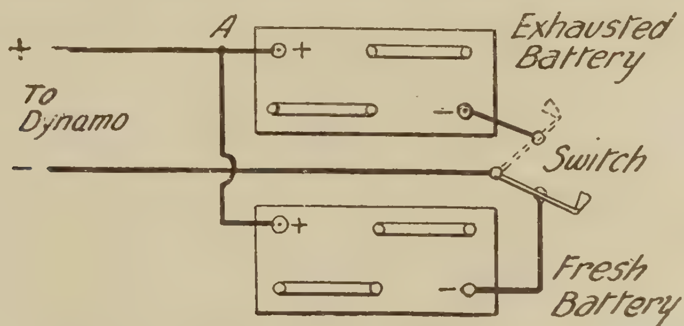


Fig. 96.—Starting Car Engine when Battery is Exhausted.

commence to charge the exhausted battery, and the engine will, of course, continue to run satisfactorily. It is better to fit a switch so that the fresh battery does not tend to discharge itself into the exhausted battery whilst being used for starting purposes, and to enable the dynamo leads to the battery to be quickly transferred, when the engine has started, to the exhausted battery.

Fig. 96 shows a simple arrangement for starting the engine of a car with exhausted battery. The positive leads are joined together at A by means of a temporary connection. A switch is fitted between the negative terminals so as to be able to switch the engine over from one battery to the other.

General Notes on Coil Ignition

(1) *Lubrication.*—It is not often necessary to lubricate the rotating distributor shaft and its driving gears, for which reason this important operation is often neglected. *A few drops of engine oil should be given every 500 miles*; about 8 to 10 drops is the correct quantity.

Spiral gears, together with the advance ring and yoke, operate in a light grease. The distributor housing should be filled with a medium-body grease once every season in order to lubricate the lower ball-bearing on the distributor shaft.

A small amount of light grease or vaseline should be applied to the surface of the contact-breaker operating cam each 2,000 miles.

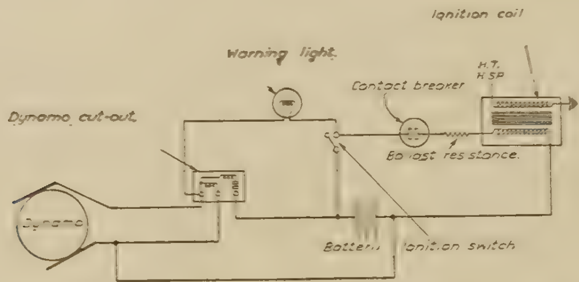


Fig. 97.—The B.T.H. Connection Diagram for the Warning Light.

The rubber track in the distributor head should receive a very small amount of vaseline applied occasionally during the first 2,000 miles; as soon as the track becomes glazed no further lubrication is necessary.

(2) *Current Consumption.*—At 1,000 r.p.m. of the engine the Delco-Remy current consumption is $1\frac{1}{4}$ amperes. In the case of the C.A.V. battery-

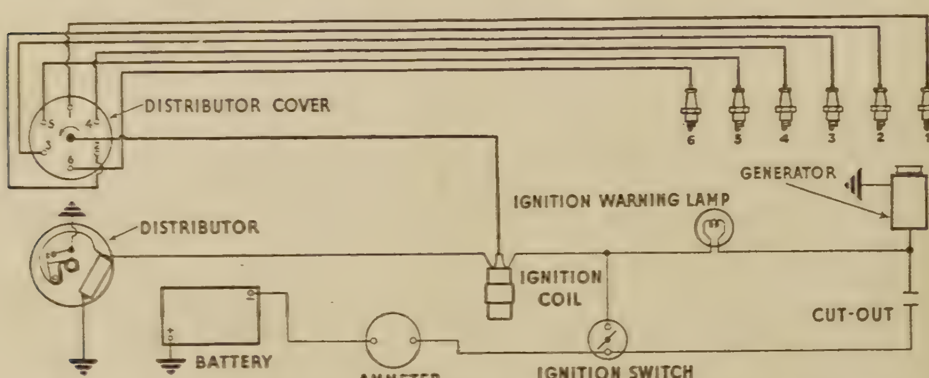


Fig. 98.—The Vauxhall and Bedford Ignition Systems, showing wiring up of Ignition Warning Lamp.

ignition system, at 1,000 r.p.m. the unit uses from 5 to 7 watts for the 6-volt model, and from 12 to 15 watts for the 12-volt model.

(3) *Fuses.*—There are no fuses in the ignition circuit, so that if a fuse blows look for the trouble in the lighting or charging circuits.

Red Lamp Indicator

In most cars a red lamp is fitted on the dashboard and lights up when the engine is running very slowly or is stopped with the ignition " on."

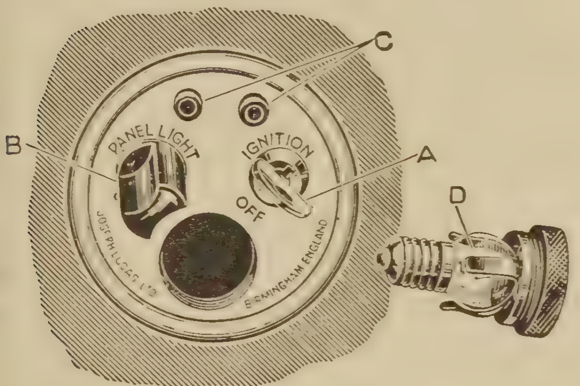


Fig. 99A.—One model of Lucas Red Warning Lamp.
A, Ignition Switch Key. C, Pilot Lamp Sockets.
B, Panel Light Switch. D, Red Lamp Bulb.

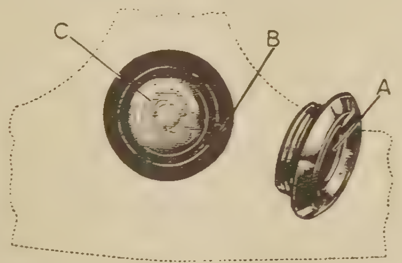


Fig. 99B.—The Lucas Screw-in-type Red Warning Lamp.
A, Warning Lamp Front.
B, Tab to facilitate Bulb Removal.
C, Bulb.

Failure of the lamp does not affect the ignition. When a red lamp is not fitted, if the switch is left " on " the battery will be slowly discharged through the high-resistance unit.

Fig. 97 shows the connection diagram for the warning light in the case of the B.T.H. coil-ignition system. It will be observed that there is a ballast resistance between the primary coil and the contact breaker, to prevent damage to the windings and rapid discharge of the battery should the ignition switch be left on with the engine stopped.

The Lucas red warning lamp is mounted on the dashboard panel, as shown in Fig. 99A. The lamp D is of the pea-bulb screw-in type and it fits in the circular front shown in the lower middle portion of the diagram. The screw-in front type of red warning lamp is shown in Fig. 99B.

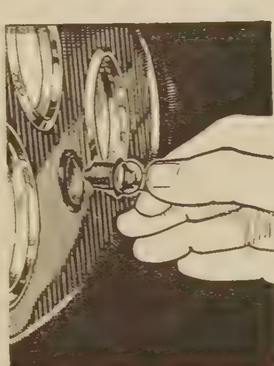


Fig. 100.—Removing Red Warning Bulb.

Fig. 100 shows the method of removing the ignition warning bulb on later models, by means of the tab provided for this purpose.

The bulb used is generally one of 2·5 volts and ·3 watt rating, but in some recent cars it is either 6 or 12 volts, ·3 watt.

Red Warning Bulb Connections.—The red lamp is connected between the ignition switch (contact-breaker connection side) and the dynamo terminal

connection on the cut-out. This will be clear from Fig. 98. It will be seen that when the ignition switch is closed and the dynamo is at rest or running too slowly to operate the cut-out contacts, the current will flow through the red lamp to the dynamo and thence to earth. As soon as the engine speed is high enough for the dynamo to commence charging the battery, the cut-out contacts close and there is then a direct connection from the dynamo through the ignition switch to the battery. No current therefore flows through the red lamp and it then " goes out."

CHAPTER 4

MAGNETO IGNITION

ALTHOUGH replaced to a large extent on motor-cars and commercial vehicles, the magneto is still to be found on some vehicles in service and on petrol-driven tractors, portable engine-driven garage plant, etc. It is important, therefore, that the motor mechanic should be fully acquainted with the construction, maintenance, and testing of modern magnetos. The original Bosch magneto established a world-wide reputation for its efficiency and reliability over a very long period, until the cheaper coil-ignition system largely supplanted it. The earlier magnetos were of the rotating armature pattern with a high-tension carbon brush that rotated within the distributor cover making frictional contact with the inside contacts ring, to which the sparking-plug cables were connected. The later magnetos include the rotating armature type with spark gaps or "jump-spark" type distributor; the rotating magnet, fixed-armature pattern; the polar-inductor and the vertical- or camshaft-type magnetos. The latter are designed to replace the coil-ignition distributor-contact breaker unit and are therefore made to couple up to the same driving (half-speed) shaft. These magnetos compare in performance very favourably with coil-ignition units; moreover, they are independent of the battery condition, so that the system is more reliable under all operating circumstances.

The principles of magneto ignition can readily be mastered, once those of battery ignition have been clearly understood. It is only necessary to point out that in the case of the coil-ignition unit the source of electrical energy is the battery, and that the separate components are as follows:

(1) The battery.
(2) The H.T. coil.
(3) The contact breaker and H.T. distributor unit.

It will be observed that these three components are separate. In the case of the magneto all three components or their equivalents are arranged in a single unit mounted on and driven off the engine.

Instead, however, of employing a battery to supply the electrical energy for ignition, a small electrical generator, or dynamo, is arranged within the unit, so as to generate its own electrical impulses.

The magneto, then, is self-contained, and functions without the aid of a battery; the latter is then used purely for lighting and starting purposes.

The only technical point of difference between magneto- and battery-ignition units lies in the adoption of the generator for the battery and its combination with the coil and contact breaker.

Referring to Fig. 101, which illustrates the principle of magneto ignition, if this be compared with the corresponding diagrammatic sketch for battery ignition (Fig. 19 on page 25), it will be observed that the only principal point of difference lies in the substitution of the electrical generator D (Fig. 101) for the battery B (Fig. 19).

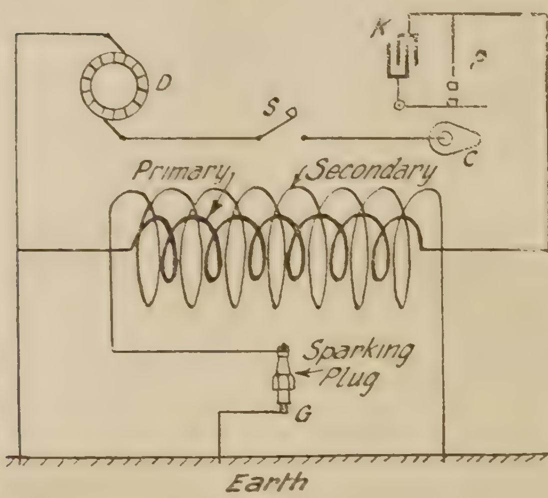


Fig. 101.—Illustrating the Principle of Magneto Ignition.

The generator D does not give a continuous current, however, but, with the ordinary type of horseshoe magnet and H-section armature, a current alternating to maximum values twice per revolution, and also to zero values twice per revolution. When the current is at its maximum value, the contact breaker is arranged to break the primary circuit, and thus produce the maximum possible spark intensity.

The armature of the magneto consists usually of a soft-iron laminated cylinder of H section, wound with both primary and secondary wires. It rotates in ball bearings between the poles (suitably shaped so as to give the greatest magnetic flux and the smallest air gap) of a fixed permanent magnet made of cobalt or tungsten steel.

The rotating unit comprises the armature, primary and secondary coils contact breaker, and H.T. distributor brush. The magnets, condenser, distributor disc, and contact-breaker cams are fixed.

A Typical Magneto Lay-out

Having briefly outlined the principle of the magneto, let us now refer to the general arrangement of a typical four-cylinder magneto, as shown in Fig. 102, namely the Bosch magneto.

Commencing from the lower left-hand portion of the diagram, we observe the armature shaft, with its tapered portion (left) for attaching the driving flange from the engine secondary shaft. The primary winding is shown at *a* and, it will be observed, consists of a few turns of heavy-gauge wire. The large number of turns of fine wire indicated at *b* constitutes the secondary coil windings; *one end of the primary is connected to one*

end of the secondary. The other end of the primary *is* " *earthed*" to the engine frame. The *other end of the secondary* carries the high-tension current to a brass segment, or segments, arranged in an insulating ring—this is shown by the black V-pulley-shaped component on the left at P. The condenser K in Fig. 102 corresponds to K in Fig. 19. From the slip ring P, the H.T. current is collected by the spring-loaded carbon brush E, which leads it to another spring-loaded carbon brush C in electrical connection with the rotating distributor brush B. From the carbon brush B the H.T. current is passed, in turn, to each of four brass segments. as at

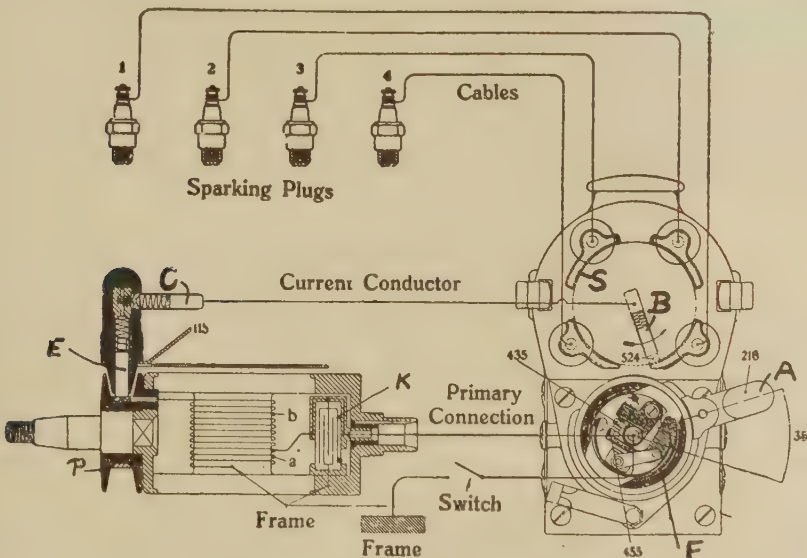


Fig. 102.—Showing Layout of a Typical Magneto (Bosch).

S, held in the insulated distributor unit. Each of these segments is in electrical connection with its own H.T. cable and sparking plug (shown at 1, 2, 3, 4).

The contact-breaker unit is connected to the common end of the primary and secondary wires at its centre. This unit rotates solidly with the armature shaft. The contacts are shown at 435 and 455 (Fig. 102). The former contact is rigidly fixed to a block on the disc driven by the armature shaft. The latter contact is carried by an elbow lever or angle-shaped arm pivoted at its centre, and carrying a small fibre pad at its other end. The fibre pad is kept outwardly pressed by means of a curved piece of flat spring, somewhat resembling a clock spring.

There are two metal pieces, as at F, forming the cams for operating the contact breaker; for when the moving arm with its fibre pad encounters one of these fixed cams, it causes the contact 455 to separate from the other contact 435. On passing off this cam, the contacts come together again.

As there are two cams F, twice every revolution of the armature shaft there are two " makes " and " breaks " in the primary circuit, and since the *H.T. distributor arm rotates at one-half the speed of the armature shaft*, there are two sparks (namely, on consecutive segments of the H.T. distributor) each revolution; this arrangement of sparking intervals at 180° apart is what is required for a four-cylinder engine. In this case the armature is driven at engine speed.

The only other important items in the magneto arrangement shown are the *safety gap*, 115, and the *ignition switch*. The former consists of a safety sparking gap, within the dust cover, to allow any excessive-voltage high-tension sparks to discharge across the gap between C and 115—which is connected to earth—so as to protect the armature and conducting parts of the magneto against any possibility of excessive voltage, and therefore of any tendency to burn out the coil windings and leads.

The switch is for the purpose of disconnecting or switching off the ignition by making the primary-circuit connection with the " earth " or frame.

Typical Commercial Magnetos

Although, as mentioned earlier, the magneto has been largely superseded by the coil-ignition system, there are many vehicles, including tractors, still in active service which are fitted with magnetos of the rotating-armature and rotating-magnet types. It is therefore proposed to describe representative types of the rotating H.T. brush and also the H.T. rotor jump-spark kinds.

The Lucas Type G.J.4 Magneto

This modern design of magneto, which has been fitted to Fordson tractors with very satisfactory results, is shown externally in Fig. 103 and sectionally in Fig. 104. It is of robust design and construction, and performs arduous service.

The operation is based upon the previously explained principles, namely the rapid change of the magnetic flux in a laminated-iron core carrying the rotating armature windings. The latter comprise the primary and secondary windings.

This type of magneto is fitted with *an impulse starter* in order to provide good sparking characteristics at low starting speeds. As soon as the engine begins to " fire," the impulse starter is automatically cut out of action.

A timing lever is provided on the contact breaker in order to advance and retard the ignition. To advance, the timing lever is moved upwards; to retard, it is pushed downwards.

To switch off the ignition the timing lever is moved to the fully-retarded position, where it meets a short-circuiting strip on the contact-breaker cover, thus earthing the " live " side of the contact breaker.

Before starting the engine, the timing lever must be *moved to the mid*

position; after starting, the timing lever should be advanced as far as possible before knocking occurs.

Maintenance of Magneto.—The distributor unit is of the jump-spark kind, as distinct from the usual wipe-contact rotor method.

Distributor.—Occasionally remove the distributor cover by pushing aside its two securing clips and wipe the inside with a dry, clean cloth. Clean the metal electrodes inside the moulding and also the rotating electrode. If necessary, use a cloth moistened with petrol. Clean the outside of cover, more particularly the spaces between the high-tension leads.

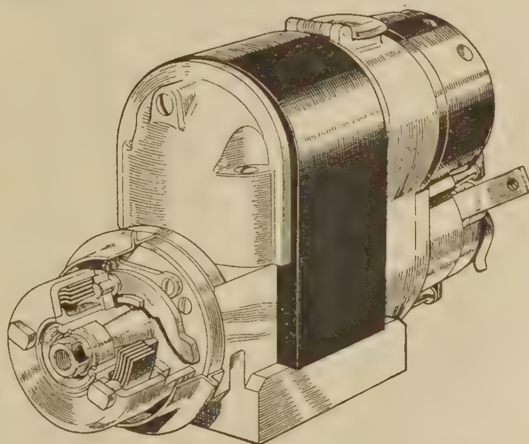


Fig. 103.—The Lucas G.J.4 Magneto, showing also the Impulse Starter.

The H.T. Pick-up.—Remove the driving-end cover which is held by three screws, when the pick-up will be accessible and can be removed by withdrawing its two securing screws. Wipe the pick-up clean and polish with a clean, dry cloth. The pick-up brushes must slide freely in their holders; if dirty, clean with petrol. If the brushes are worn to an appreciable extent, they should be replaced. Before replacing the pick-up, *clean the slip ring* by inserting a soft rag and at the same time turning the engine.

The Contact Breaker.—The usual arrangement of contact breaker is employed, as shown in Fig. 105. The contacts should be examined, by first swinging aside the securing spring. If found to be dirty, they should be cleaned with a petrol-moistened rag, and if pitted, trued with a fine Carborundum stone. The contacts are rendered accessible for cleaning by first unscrewing the central hexagon-head screw (Fig. 105) and then pulling the complete unit off the taper shaft that it fits. Next push aside the locating spring and prise the rocker arm off its bearing, when the contacts will become accessible for cleaning, as shown in Fig. 106.

When replacing the contact breaker the projecting key on the tapered portion of the contact-breaker base must engage with the keyway cut in the armature spindle; otherwise the timing and efficient operation of the magneto will be upset. The hexagon screw should be tightened with special care; it must be neither too loose nor too slack.

The gap to which the contacts must be set is ·012 in.; a gauge of this thickness is supplied by the manufacturers. To adjust the gap, rotate the engine by hand until the contacts are fully opened. Then slacken the lock-nut on the fixed contact bracket and turn the hexagon head of the contact screw until the gap is correct. Finally, tighten the lock-nut.

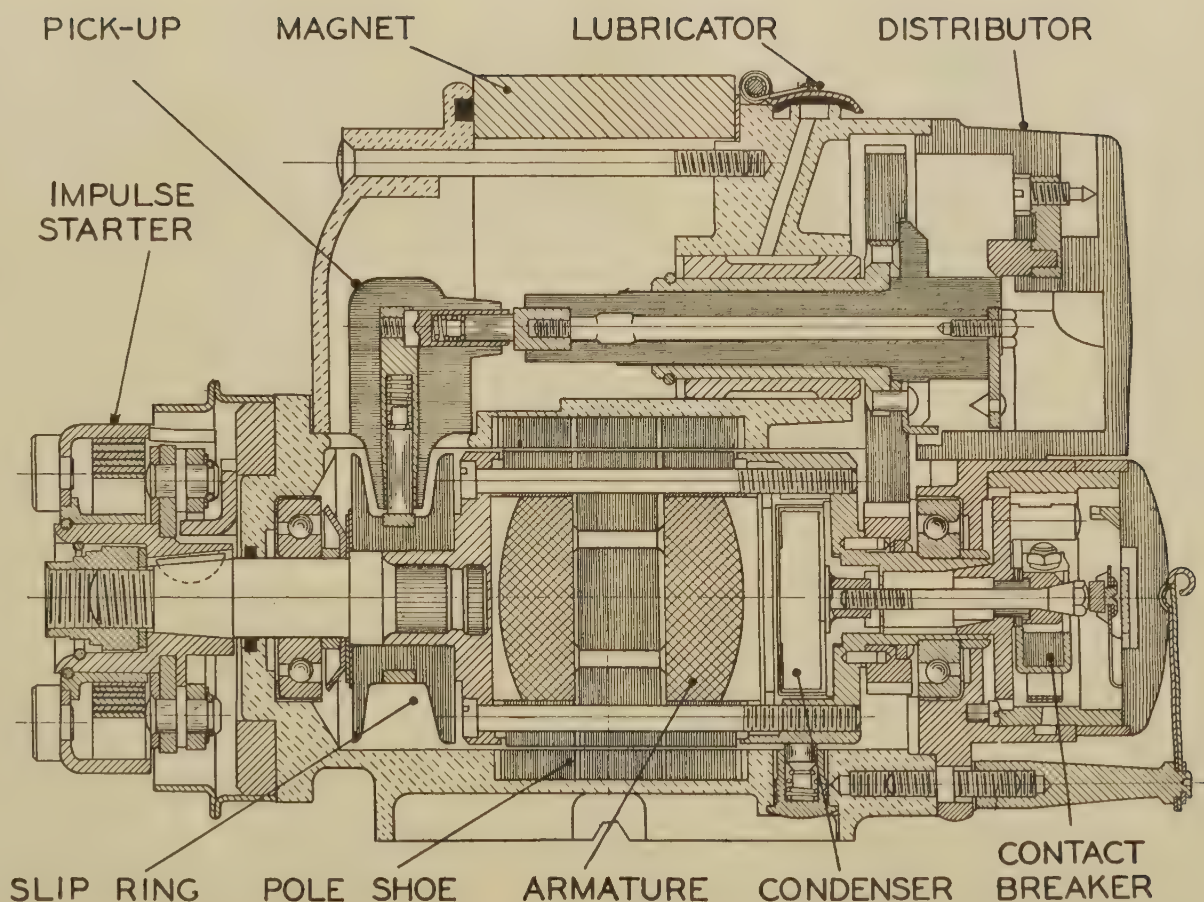


Fig. 104.—The Lucas Type G.J.4 Magneto in Sectional View.

Sparking Plugs.—The plugs used with this magneto should have a gap of ·030 in.

Lubrication.—The armature shaft runs in ball bearings which, before leaving the manufacturer's works, are packed with grease. After every two years of service these bearings should be cleaned in paraffin and re-packed with high-melting-point grease.

The distributor gear bearings should be lubricated every 1,000 miles with 2 or 3 drops of machine oil through the lubricator provided.

The cam ring is lubricated by a felt member fitted in a pocket in the contact-breaker housing. The cam ring should be withdrawn every 5,000 miles, and a few drops of thin machine oil added to the felt.

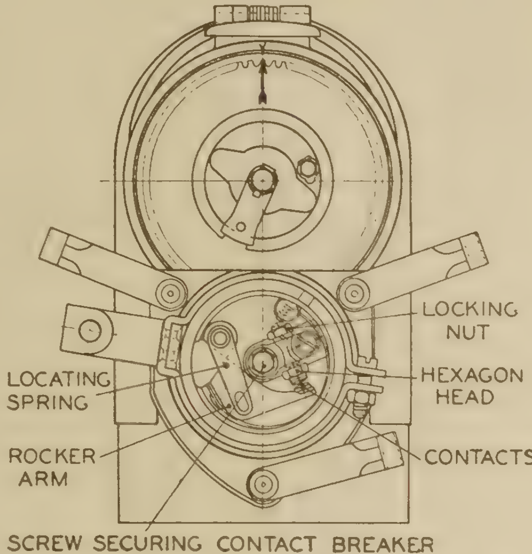


Fig. 105.—The Contact-breaker End of the G.J.4 Magneto.

About every two years, or when the engine is overhauled, the cover of the impulse starter should be removed and the moving parts of the coupling and between the springs lubricated with a thin oil.

Timing the Magneto.—If for any reason it is believed that the timing is incorrect, it will be necessary *to remove the magneto* by taking out its four security bolts and disconnecting the timing control.

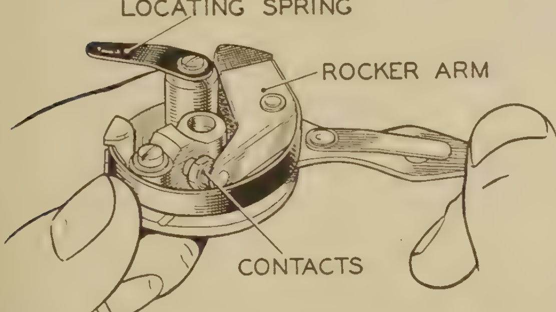


Fig. 106.—Showing detached Contact-breaker Unit and Method of removing the Rocker Arm for cleaning the Contacts.

To check the timing, first ascertain the firing order of the cylinders, and see that the H.T. cables are connected correctly with the distributor. Then revolve the engine crankshaft by hand until No. 1 piston is on its top dead centre (compression stroke).

The timing lever on the magneto should be in the retarded position. The distributor cover should then be removed and the armature turned until the arrow marking on the distributor gear coincides with the mark

on the magneto body. In this position of the armature the dogs on the impulse coupling are in the horizontal position.

Now refit the magneto to the engine. If the coupling on the engine does not coincide with the magneto driving dogs, then the engine needs re-timing.

Magneto Faults, Location, and Remedy (G.J.4 Type).—If the fault is believed to be due to the ignition, as distinct from the carburation system, then the following notes will be found useful in ascertaining the location of the fault or faults.

If *misfiring occurs in one cylinder*, either the sparking plug or its H.T. lead are at fault. Any signs of perishing or cracking of the H.T. leads may be the cause; new cables should then be fitted.

When the plug is suspected it can be removed and, with the metal body placed on the cylinder head, the spark can be observed when the engine is cranked. Alternatively, a new plug can be substituted to check whether the one in question is faulty.

If the engine misfires only when the engine is running on full throttle, it is very possible that the plug gap is too wide.

Complete ignition failure may be checked by removing one H.T. cable from its plug terminal and holding it near to the cylinder metal. A spark should then pass between the cable connector and the cylinder when the air gap is about $\frac{1}{8}$ in. If no sparking occurs, examine first the short-circuiting trip; this may be touching the pillar of the contact-breaker-cover securing spring.

If the fault has not been found, remove the contact-breaker cover and, whilst the engine is cranked slowly, examine the action of the contact-breaker arm; if it remains permanently open, its control spring cannot be operating satisfactorily. There may be dirt or other deposit on the bearing of the arm, and if suspected the contact breaker should be removed and pressure applied to the fibre heel to check whether the points open and close correctly. If at all sluggish, remove the contact-breaker arm and examine the steel pin on which it works. If necessary, clean the pin with paraffin or petrol, and gently scrape off any deposits that are not removed by the liquid used.

The location and remedy of ignition faults can be more readily effected by reference to the table on page 103.

The Simms Magneto

This well-known magneto is used on certain commercial vehicles, and has also been fitted to certain motor-cars in the four- and six-cylinder models.

In general design the Simms magneto follows accepted practice, and in regard to the high-tension current this is distributed by the jump-spark method. The timing of the ignition can be varied either by hand or by means of an automatic advance device supplied by the makers.

MAGNETO FAULTS AND REMEDIES

Condition	*Method of Detection of Possible Causes*	*Remedy*
Engine will not fire.	Controls not set correctly for starting.	See that ignition is switched on, petrol turned on, and everything is in order for starting.
	Dirty or pitted contacts.	Clean contacts.
	Contact breaker out of adjustment. Turn engine until contacts are fully opened and test gap with gauge on spanner.	Adjust gap to gauge.
	H.T. leads perished or worn.	Renew cables.
Engine misfires.	Dirty or pitted contacts.	Clean contacts.
	Contact breaker out of adjustment. Turn engine until contacts are fully opened and test gap with gauge on spanner.	Adjust gap to gauge.
	Remove each sparking plug in turn, rest it on the cylinder head and observe whether a spark occurs at points when engine is turned. Irregular sparking may be due to dirty plugs or defective H.T. cables. If sparking is regular at all plugs, the trouble is probably due to engine defects.	Clean plugs and adjust the gaps to about ·030 in. Replace any lead if the insulation shows signs of deterioration or cracking. Examine carburettor, petrol supply, etc.

[*J. Lucas, Ltd.*

The four-cylinder magneto is arranged to run *at engine speed*, whilst the six-cylinder type runs at *one and a half times* engine speed.

The magneto of the four-cylinder type is given a maximum angle of advance of 30°, but if required as much as 55° can be obtained. The magnetos described have been designed to give a 5½-mm. spark in air at approximately 30 r.p.m. when in the *fully advanced* position of the timing lever. In the *fully retarded* position where the magnetic field through the armature is not so strong, the magnetos give a 5½-mm. spark at 50 r.p.m.

The distributor brush is driven at one-half the armature speed by means of a non-metallic half-speed gear. Noise is reduced still further by making the contact breaker very light to reduce its impact.

The Simms magneto is shown in sectional view in Fig. 107, the following being a key to the numbers on this illustration.

2000, Distributor.
2002, Distributor Terminal Nuts.
2003, Half-speed Wheel.
2005, Switch Terminal Nuts.
2010, Distributor Carbon Holder.
2012, Distributor Carbon and Spring.
2013, Timing-lever Cover Complete.
2014, L.H. Contact Breaker.
2026, Earth Brush.
2032, R.H. Contact Breaker.
2038, Timing Lever, Complete.
2039, Timing Lever, Segments.
2045, Driving Spindle and Disc Nut.
2046, Driving Spindle and Disc Washer.

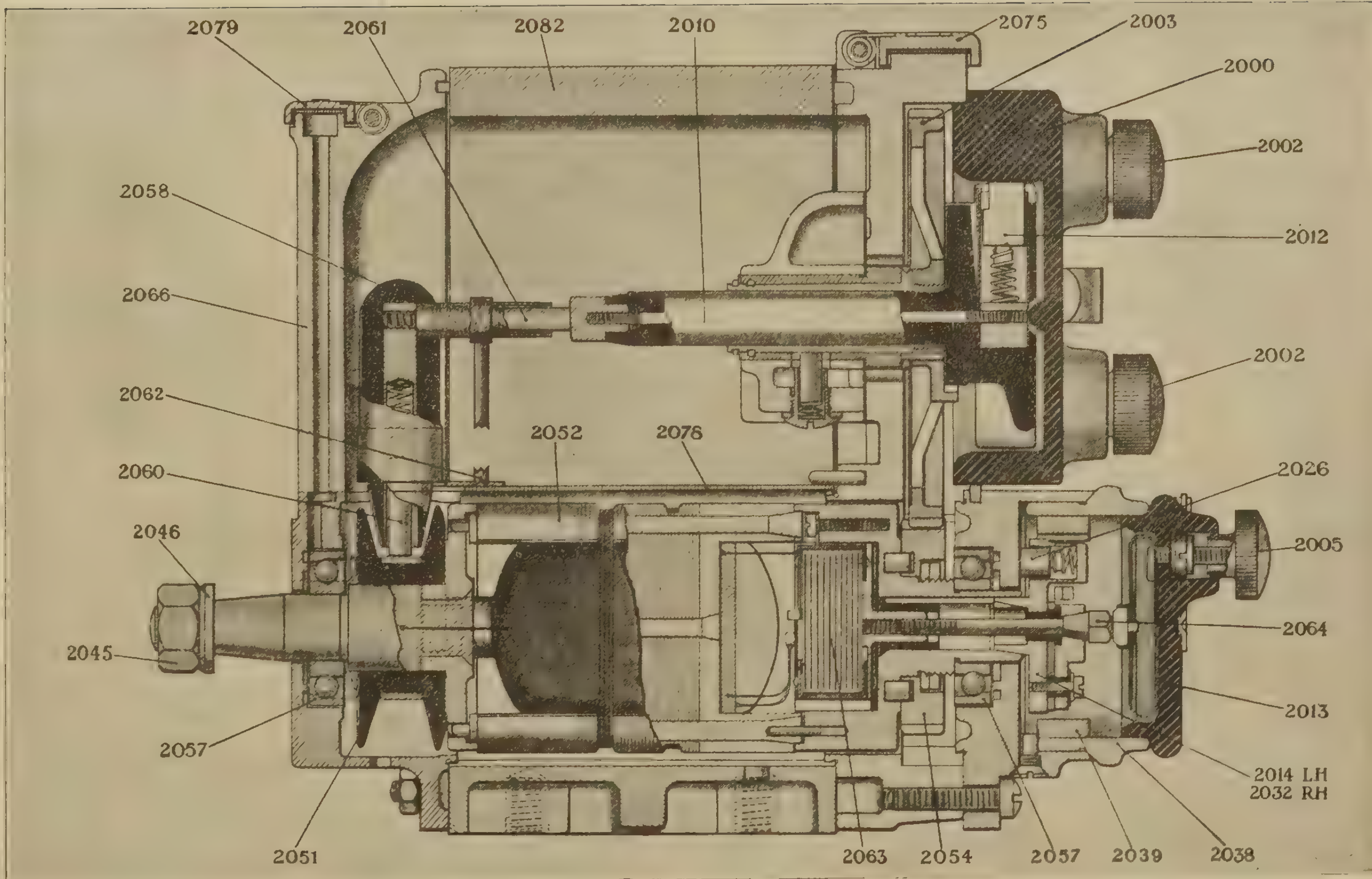


Fig. 107.—The Simms S.R.4 Magneto in Sectional View.

2051, Slip Ring.
2052, Wound Armature Core.
2054, Full-speed Pinion.
2057, Cage and Balls.
2058, Collector Carbon Holder.
2060, Collector Brush and Spring.
2061, Conductor.
2062, Spark-gap Plate.
2063, Condenser.
2064, Contact-breaker Retaining Screw.
2066, Cover Plate.
2075, Distributor End-plate Oil Flap.
2078, Cover Plate for Armature.
2079, Cover-plate Oil Flap.
2082, Magnet.

The B.T.H. Type G.A.4 Magneto

This is used on medium-speed engines and for tractors. It is of the standard rotating armature pattern and is base mounted.

Fig. 108 shows the external view of the two alternative models, for fixed and variable ignition timing respectively.

An exploded view of this magneto, as fitted with an impulse starter, is

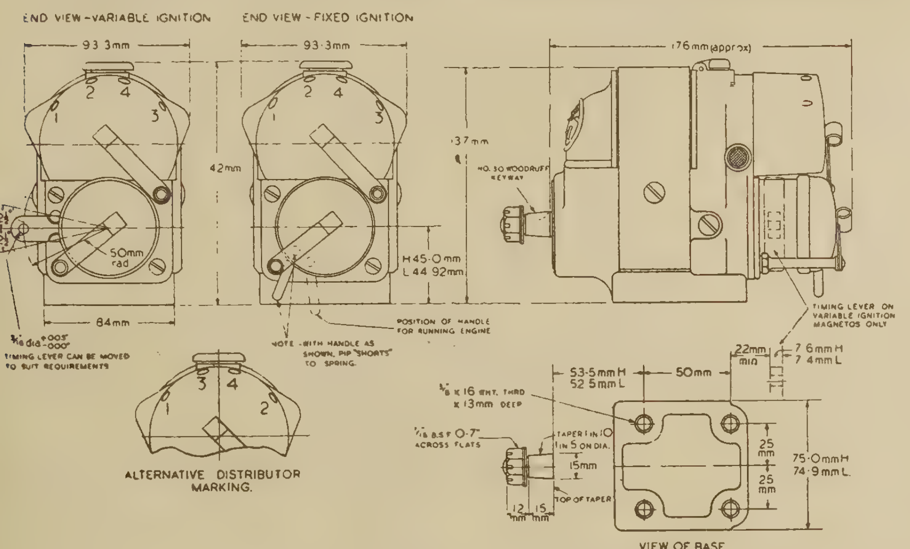


Fig. 108.—The B.T.H. Type G.A.4 Magneto.

given in Fig. 109; this illustration will enable the service engineer to identify all of the individual components.

Distributor.—A carbon-brush type of distributor is fitted. This has a robust moulding of smooth contour, which is particularly suitable for conditions where the magneto is exposed to rain, sea-spray, or extreme humidity. It is secured in position by means of a pillar and spring.

Contact-breaker Earthing Device.—An effective short-circuiting switch is incorporated in the contact-breaker cover. This consists of a short

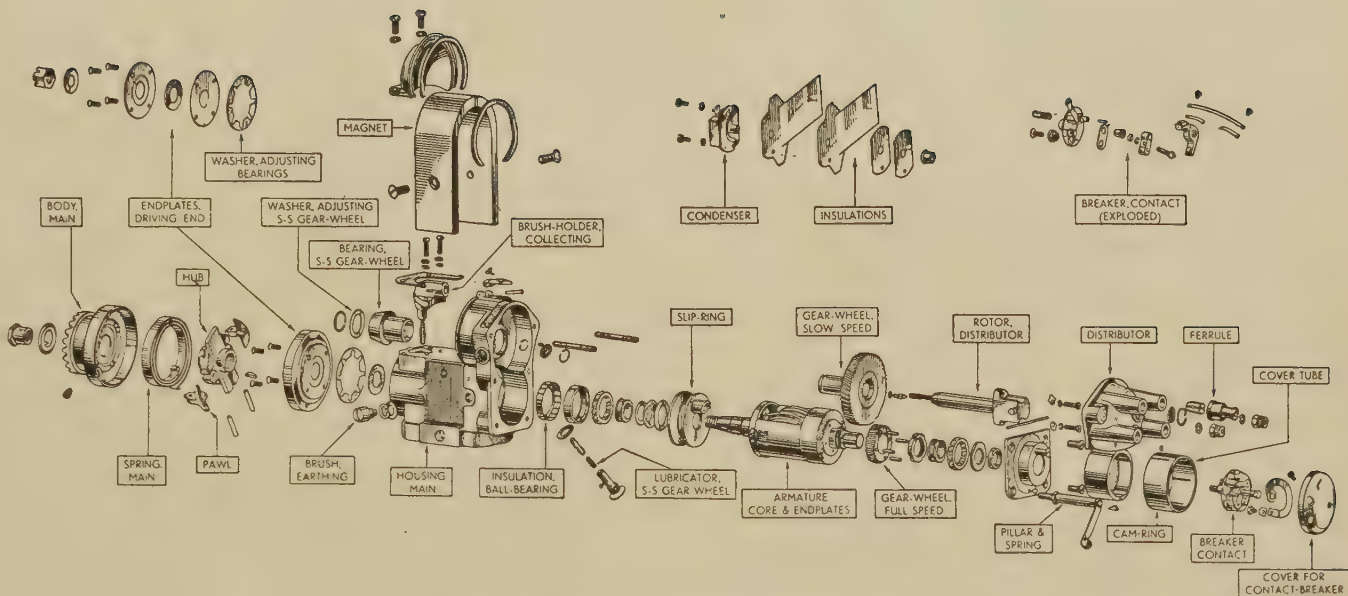


Fig. 109.—The B.T.H. Magneto in Exploded View.

metal stud projecting from the moulded cover, the stud making contact with the cover-retaining spring when the cover is turned to the "stop" position by means of the short steel handle provided. Alternatively, a moulded cover can be supplied suitable for use with a separate earthing switch.

Safety Spark Gap.—Should the high-tension circuit be interrupted for any reason, such as by one of the leads becoming detached from a sparking plug, the magneto will continue to generate a high voltage which may endanger the insulation of the machine. To prevent this, a safety spark gap, across which any excessive voltages are discharged, is provided at the collector end of the distributing brush holder. The high-tension electrode of the spark gap is a brass washer on the end of the brush-holder insert, while the earth electrode is located in the top of the magneto housing.

Maintenance.—It is recommended that the magneto should be inspected every three working months or at the time of engine overhaul.

The rotating armature of the magneto is fitted with two ball bearings which are packed with lubricant before the magneto leaves the works, and no further lubrication should be necessary for a very long period.

The only part requiring lubrication is the distributor gear-wheel bearing; eight drops of light oil poured into the oil well at the distributor end of the magneto each working week, or before re-starting if shut down for more than two weeks, will suffice.

The contact points of the contact breaker must be kept absolutely free from oil. This is of the utmost importance, because any oil on the contacts becomes oxidised and prevents good electrical contact between the points when closed. The operation of the magneto may be impaired considerably due to this cause.

Distributor and Brush Holder.—Remove the distributor and clean the inside with a cloth damped with petrol. Any carbon dust or foreign matter that may accumulate inside the distributor is liable to cause leakage, the symptoms of which are misfiring or poor starting. In a similar manner wipe the surface of the brush holder, particularly around the high-tension brush. Make sure that the carbon brush is quite free in its brush box.

Slip Ring and Collector Brush Holder.—Remove the aluminium dust cover at the driving end of the magneto (taking care not to damage the compressed-cork sealing washers) and take out the collector brush holder, which is secured to the top of the housing by two screws.

With a cloth damped with petrol wipe off any dust from the cone of the collector brush holder. Do not, unless absolutely necessary, remove the carbon brush from the collector moulding.

Clean the flanges of the slip ring in a similar manner. This can be done by *lightly* pressing one corner of the cloth between the slip-ring flanges and slowly turning the engine crankshaft.

Contact Breaker.—The contact breaker is readily accessible by removing

the cover, and if necessary can be withdrawn from the magneto after unscrewing the centre-fixing screw.

Examine the contacts, and if dirty the surface of each should be cleaned with a piece of very fine emery cloth or paper, care being taken to remove any emery dust which may accumulate.

Examine the bell-crank lever bearing bush, and if dry smear with a little light oil. After refitting the lever on the bush it is important that any excess oil should be wiped off. The felt lubricating wick in the bottom of the cam ring should be given a few drops of light oil.

The cam track also should be lightly smeared with oil. When refitting the contact breaker take care to locate the key on the base in the keyway of armature spindle.

The contact-breaker gap is ·012 in. The sparking-plug gaps should be ·018 in.

Location of Faults.—In the case of uneven firing, first check the sparking plugs for condition and correct gap (·018 in.).

Irregular firing may result from defective operation of the contact breaker. This should be removed and inspected. After cleaning, reset the contact gap at ·012 in. Examine and clean the high-tension mouldings.

Persistent sparking at the safety gap of the magneto indicates that there is a break in the external high-tension circuits, and the plug leads should be carefully checked over.

In the case of magnetos fitted with a contact-breaker cover carrying a lead to an earthing switch, a complete shut down of the engine has frequently been traced to the earthing lead coming into contact with the frame of the engine and thus earthing the magneto primary. The trouble can be diagnosed quickly by removing the contact-breaker cover, thus disconnecting the earthing lead from the magneto, and swinging the engine. If correct firing is then obtained, examine the earthing lead for chafing. If the magneto switch is incorporated in the lighting switch box, make certain that the end of the earthing lead is not touching other terminals or metal components.

How to Determine the Angle of Advance

Unless the flywheel is graduated for the purpose, it is not possible to determine directly the angle of advance when adjusting the ignition. Many car engines now have their flywheels marked with lines corresponding not only to the top dead-centre positions but also to the correct maximum spark-advance positions; this greatly facilitates the setting or retiming of the ignition.

In cases where such markings do not exist, the best thing to do is to determine the angles by measuring the piston position from its top dead centre in each case; each position, of course, corresponds to a definite crank angle.

The diagram given in Fig. 110 will enable anyone to at once ascertain

the flywheel or crank angle corresponding to any small amount of piston travel as measured from the top dead centre in the case of engines ranging from 3- to 8-in. cylinder stroke. As an example of the method of using this diagram, suppose we wish to find out the distance that the piston is from its top dead centre in the case of a 6-in. stroke piston with an advance of 30°. If the vertical line through the 6-in. stroke position (*a*) be followed upwards until it cuts the 30° (advance) oblique line (*b*) a point (*c*) will be found at a horizontal level practically at ½ in. The piston should therefore be ½ in. below top dead centre on its upward or compression stroke.

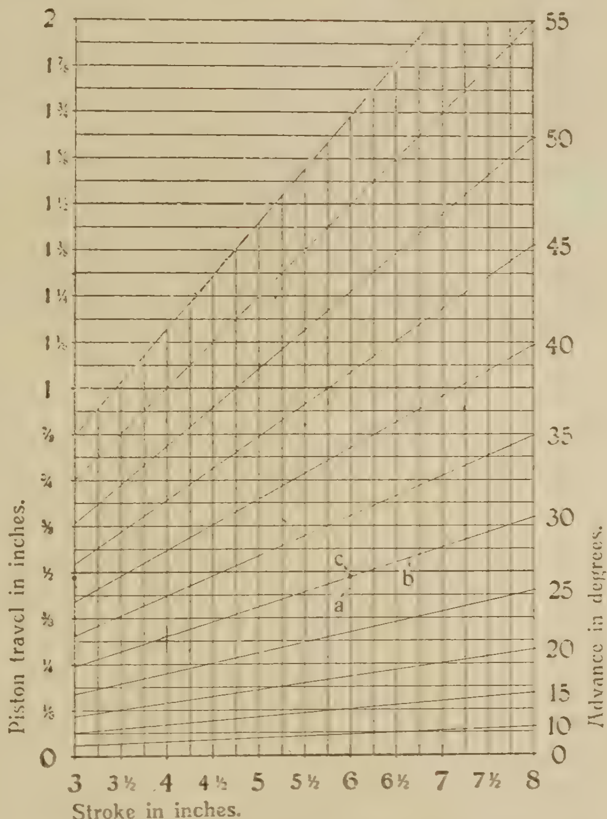


Fig. 110.—A Useful Chart for Engine Ignition-timing Purposes.

Magneto Automatic Ignition Advance

Whilst the centrifugal type of automatic ignition advance is now practically a standard feature of coil-ignition systems, it has only more recently been applied to magnetos as an adaptation in the form of a coupling device between the engine drive and the armature or rotor shaft.

The device generally assumes the form of a centrifugally-operated mechanism placed between the engine and magneto, giving an automatic timing range of 30° on the magneto spindle.

Typical examples of this device are the two models supplied by Messrs. B.T.H., Ltd., one for mounting direct on the spindle of the magneto and the other actually embodied in the design of their Type C.E. magneto.

Referring to this latter type (Fig. 111), the device is totally enclosed in a brass casing formed in two halves which are spigoted and held together by four screws. One half of the casing is secured to the main body of the

magneto and carries one of the ball bearings for the rotor shaft. The other half carries the ball bearing for the driving member of the timing device. The driving member has a standard spindle extension protruding through the brass casing.

Fig. 111.—The B.T.H. Automatic Ignition-advance Device.

The device consists of a driving plate suitably connected to the coupling on the timing shaft of the engine. This plate carries two pawls or weighted levers, each pivoted at one end and having a hardened-steel roller attached. A driven plate, fitted to the magneto shaft, carries two hardened-steel cams against which the pawl rollers bear. Springs, in conjunction with the centrifugal action of the pawls, control the angular relation between the driving and the driven plates, which are both provided with stops against which the main control springs bear. A dust-proof casing covers the whole mechanism.

When at rest, stops on the driving and driven plates are held radially apart by the main control springs, and the pawls, with their rollers in contact with the cams, are pressed against the centre boss of the magneto plate. At a given speed the pawls begin to move outwards by centrifugal action, increasing the pressure between the rollers and cams, so that the speed of the magneto plate is accelerated relatively to that of the driving plate. As the speed increases, the pawls move farther outwards until at a given speed the two plates are held against the stops through which the drive is then taken, instead of through the springs, rollers, and cams.

The control is usually packed with grease during assembly and no attention is required for very long periods. As motion only takes place dependent on engine acceleration and not on velocity, wear is negligible and the unit should outlive the motor vehicle.

A small-range hand-ignition control is also provided so that the experienced driver can alter the firing position for special conditions of load and throttle if he desires.

The Contact Breaker in Detail

In view of the fact that the contact breaker is probably the most important item of the magneto from the point of view of adjustment and attention it will be described in detail, so that the principal parts will readily be

identified. Fig. 112 shows a typical contact breaker, the principal parts being indicated by the letters and guidance lines. The centre bolt G, with a tapered part under its hexagon head, is tapped into the armature-shaft end, and holds the complete rotating contact-breaker member to the latter. If at any time it is desired to remove the contact-breaker unit bodily, all that is necessary is to take out G and pull the unit off. There is a tapered annular part on the contact-breaker disc provided with a key to ensure its correct registration with the shaft. It is therefore important to observe that this key registers with its corresponding keyway when replacing the contact-breaker unit.

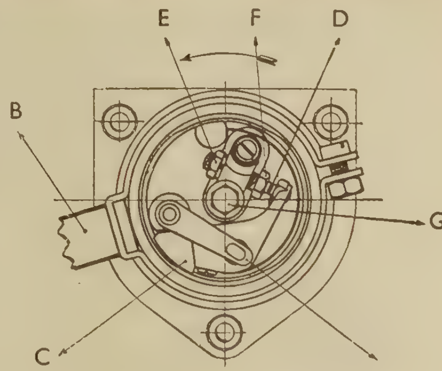


Fig. 112.—A Typical Contact Breaker, showing the Important Parts mentioned in the text.

The important parts of the contact breaker from the point of view of attention are the contact points D and the fibre (or other material) bush under the spring H. It will be observed that the spark-advance lever B can be clamped to the cam ring in any convenient position.

The Distributor Unit

This important part is concerned with the high-tension side distribution only. As we have already stated, its function or object is to collect (at its centre) the high-tension current from the secondary circuit, and to distribute this current in turn to each of the engine sparking plugs. It must therefore give each plug its high-tension current at the correct moment.

Each type of magneto gives equal distribution intervals; for example, in the case of a four-cylinder engine the intervals on the distributor ring will be 90°; for a six-cylinder engine 60°, and so on.

Fig. 113 shows the distributor arrangement of a vertical four-cylinder magneto in outside pictorial view, and indicates how the cables from the distributor terminals—as shown by the four circular numbered discs above the contact breaker—are connected to the sparking plugs. The latter diagram shows also how the metal bodies of the sparking plugs are "earthed" to the engine frame (as indicated by the shaded lines), and the magneto switch is also connected to earth on one of its terminals from the contact-breaker cover and cable, 2. The frame of the magneto also is earthed.

The distributor cover, containing the brass segments over which the spring-loaded H.T. carbon brush rotates, is made of a moulded insulating material combining hardness with strength. This unit can readily be detached in most designs, merely by releasing two spring clips.

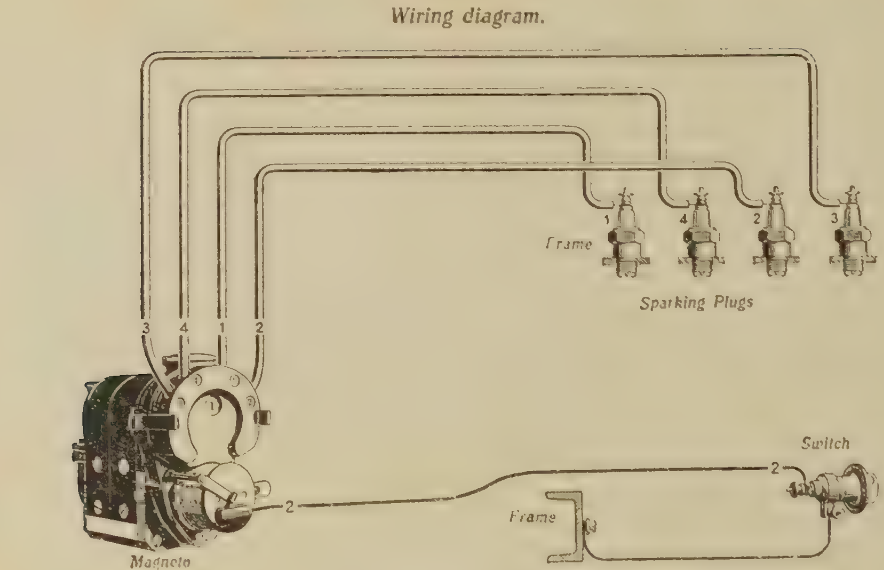


Fig. 113.—The Distributor and Switch Connections.

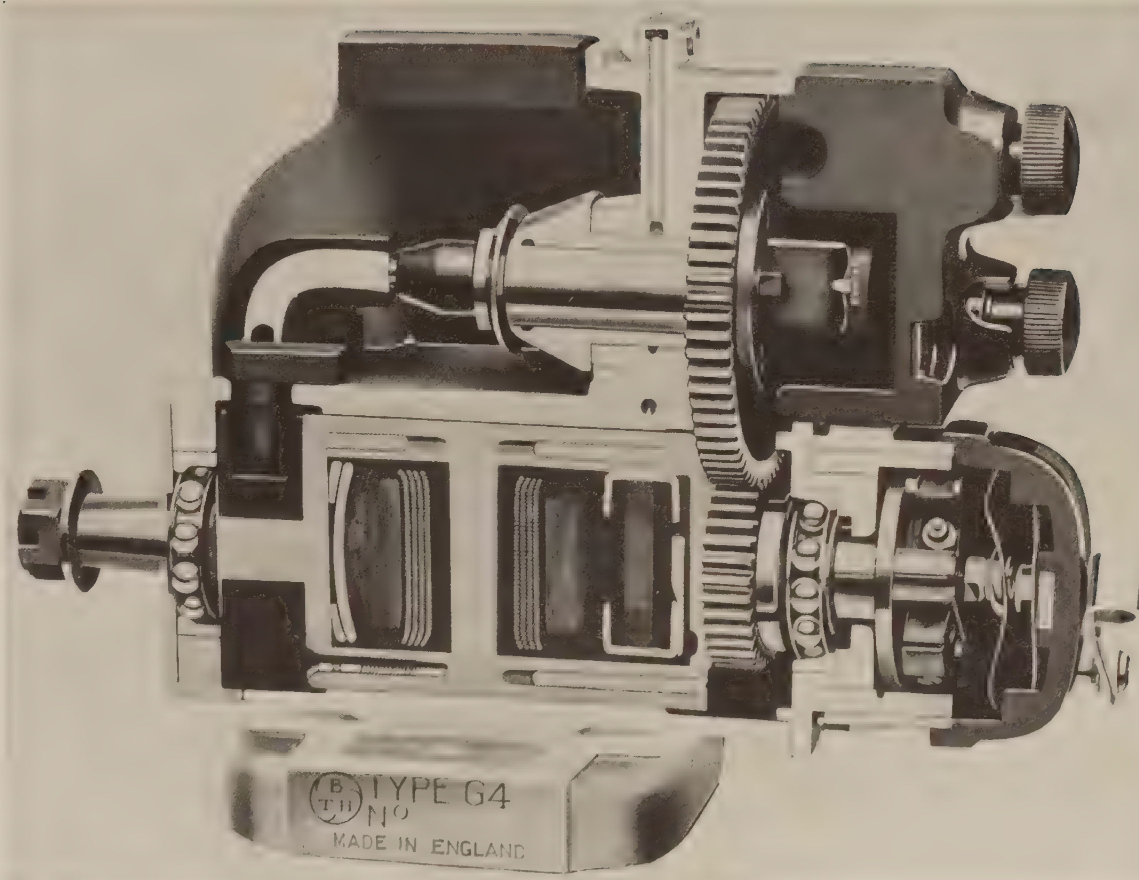
The Lucas Jump-spark-type Magneto

As mentioned earlier, the wipe-contact or rotating carbon brush of the distributor was subsequently replaced by the jump-spark rotor arm. A magneto that used this method and was widely employed on many British cars was the Lucas type shown in Fig. 114; the covers are shown removed to disclose the rotor arm and contact breaker respectively.

Maintenance of Magneto Distributors

Referring to the example shown in Fig. 114, the distributor, the distributor rotating arm D, and, at the driving end of the magneto, the end cover and the pick-up (in certain models the last two are combined in one piece), should each in turn be removed, wiped clean, and polished with a fine, dry cloth. It is a simple matter to withdraw these components. The distributor can be removed by swinging the steel holding-on spring to one side (or, in one or two models, by removing the thumb nuts).

With machines of the jump-spark type, the inside of the distributor moulding A, and the distributor rotating arm D, should be wiped clean with a cloth moistened with a few drops of petrol. It is very important to remove all traces of deposit or other foreign matter from the inside of the distributor moulding, particularly from between the metal electrodes. Neglect to do this may result in the failure of the moulding. Care must be taken, after cleaning, that the distributor is quite free from petrol before replacing it on the magneto.



THE B.T.H. TYPE G4 BASE-MOUNTED MAGNETO.

After long service, owing to the *arcing effect of the spark from the rotor-arm metal* to the distributor segments, the surfaces become pitted or irregular and worn. If the sparking gap has been increased appreciably on this account, a new rotor arm should be fitted. Further information on this subject will be found in the preceding chapter.

With machines of the *brush type* any carbon deposit in the distributor should be wiped away, the brush track being cleaned at the same time by means of a cloth moistened with a few drops of petrol. The brush in the rotating arm should work freely in its holder; if it is clogged, remove and clean it as well as the holder. If after long service the brush is very much worn, it may be necessary to replace it.

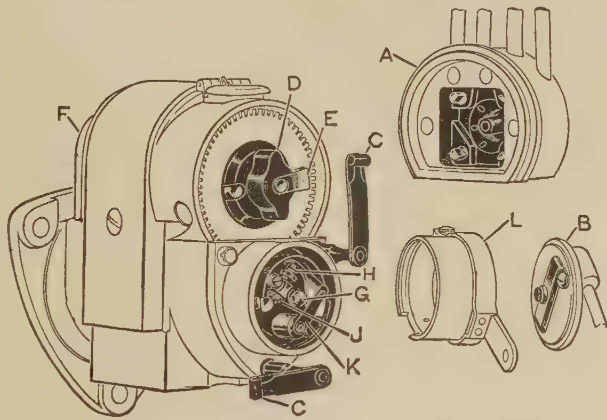


Fig. 114.—Lucas Car Magneto (Jump-spark type) with Distributor, Contact-breaker Cover, and Cam Ring removed.

A, Distributor.
B, Contact-breaker Cover.
C, Steel Springs which secure Distributor and Contact-breaker Cover in position.
D, Distributor Rotating Arm.
E, Metal Electrode.
F, Driving-end Cover.
G, Contact-breaker Securing Screw.
H, Contacts.
J, Locking Nut.
K, Locating Spring.
L, Cam Ring with Timing Lever.

Before replacing the distributor, clean the outside, particularly the spaces between the H.T. leads.

Next, remove the end cover and pick-up (in most models this component is secured to the magneto body by means of two screws) and clean them in the same manner, being sure to see that the brushes slide freely in their holders. Before replacing these parts, the slip-ring track and flanges should be cleaned by holding a soft cloth by means of a suitably shaped piece of wood on the ring while the engine is slowly turned round by hand.

Contact-breaker Maintenance

In addition to the detailed maintenance instructions that are given in this chapter for certain commercial magnetos, the following notes may be found useful. The example illustrated in Fig. 114 has been selected to show the various items of maintenance and adjustment, and in general this information is applicable to other magnetos of the rotating-armature pattern.

Swing aside the flat holding-on spring retaining the contact-breaker cover, and then remove the cover, when the contact breaker will be exposed to view. It is essential that the contact breaker should be kept spotlessly

clean; above all, the contact points themselves must be free from all traces of oil.

If it is found upon examination that they are burned or blackened (probably owing to the presence of oil or dirt at some time or other), they may be cleaned with very fine emery cloth, and afterwards with a cloth moistened with petrol. Care must be taken that all particles of dirt and metal dust are wiped away.

To render the points accessible for cleaning, it is necessary to withdraw the contact breaker from its housing by unscrewing the hexagon-headed securing screw G (Fig. 114) by means of the magneto spanner. The whole contact breaker can then be pulled off the tapered shaft on which it fits. Now push aside the locating spring H and prise the rocker arm off its bearing, when it will be possible to begin cleaning the points.

Fig. 106 on page 101 illustrates the correct method of removing the rocker arm for the purpose of cleaning the contacts.

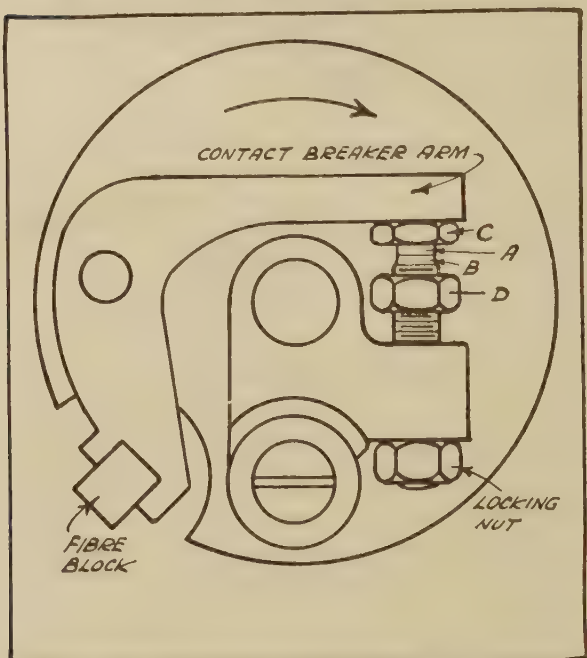


Fig. 115.—Typical Magneto Contact Breaker.

A, Fixed Tungsten Point. C, Hexagon for A.
B, Adjustable Tungsten Point. D, Hexagon for B.

When replacing the contact breaker, care should be taken to ensure that the projecting key on the tapered portion of the contact-breaker base engages with the keyway cut in the armature spindle, or the whole timing of the magneto will be upset. The hexagon securing screw should be tightened up with care; it must be neither too slack nor should undue force be used.

The gap to which the contact-breaker contacts should be set when they are fully opened is about ·012 in.; a gauge of this thickness is provided on the side of the spanner supplied with the magneto.

Providing the contact-breaker points are kept clean and, above all, as has been stated already, *free from oil*, they will probably need adjustment only at long intervals. The reader is warned that it is not desirable to alter the setting unless the gap varies considerably from the gauge. If adjustment is necessary, turn the engine round slowly by hand until the points are seen to be fully opened, then, using the magneto spanner, slacken the locking nut (Fig. 115) and rotate the fixed

contact screw by the hexagon head D until the gap is set to the thickness of the gauge; then screw up the locking nut again until it is firmly locked.

Care should be taken that the gap is not appreciably greater than the standard amount, as too wide a gap may cause undue wear and misfiring.

Lubrication of Magneto.—All magnetos of the Lucas type should receive periodic lubrication attention. The armature-shaft ball bearings are packed with grease before they leave the works and do not require oiling.

With four- and six-cylinder-type magnetos the distributor gear bearings should be lubricated about every 1,000 miles, by adding about three drops of oil through the lubricator provided. The reader is cautioned that far more trouble has been caused by excessive oiling than by too little.

Provision is made for the oiling of the cam rings in order to reduce fibre-heel wear, and consequently to enable the magneto to give longer periods of service without the need for altering the setting of the gap of the contact points.

The oiling arrangement consists of a pocket in the contact-breaker housing containing a length of felt soaked in oil. In the cam ring there is a small hole which is fitted with a wick to enable the oil to find its way on to the surface of the ring. About every 5,000 miles the cam ring should be withdrawn and a few drops of thin machine oil placed on the felt.

Timing Lucas Four- and Six-cylinder Magnetos

The following is the recommended procedure for timing Lucas magnetos of the type shown in Fig. 114.

(1) First ascertain the order in which the cylinders fire, and see that the cables from the sparking plugs are connected in correct order to the distributor. The order of firing varies in different makes of engines; the maker's instruction book should, therefore, be consulted. Also see that the direction of rotation of the magneto as marked, either on the oil cap of the machine or on the driving endplate, corresponds to the direction of rotation of the engine driving shaft from the magneto. It should be noted that in four- and six-cylinder magnetos the distributor arm revolves in the opposite direction to the armature.

(2) Revolve the engine crankshaft by hand until No. 1 piston is at the top of its compression stroke (that is, on top dead centre). On engines where the flywheel is visible most engine makers mark this position on the flywheel.

(3) Slacken the magneto-coupling securing nut on the armature spindle, or any other screws as necessary, to enable the magneto spindle to be turned independently of the engine.

(4) Remove the distributor cover and turn the magneto spindle until the distributor arm is pointing at the distributor segment connected to No. 1 sparking plug.

(5) With magnetos provided with variable ignition, the ignition control or the timing lever B should be moved to the fully retarded position; that

is, to the limit of its travel in the same direction as that in which the armature revolves.

(6) Remove the contact-breaker cover and slightly turn the armature in the normal direction of rotation until the fibre block (Fig. 115) rises on the inclined plane of the cam ring just sufficiently to separate the points. This position is the firing point, and the magneto drive should be permanently fixed in this position.

The above setting is standard for most types of engines; that is, the magneto is fully retarded when the piston is on top dead centre. In all cases, however, the engine maker's instructions should be consulted when retiming any magneto.

(7) It is always advisable to check the timing after tightening up, to ensure that no movement has taken place.

The Rotating-magnet Magneto

The ordinary rotating-armature magneto employs an armature having the primary and secondary windings wound on the rotor, so that these parts have to revolve; similarly the condenser also revolves with the armature shaft. The more robust parts such as the magnets are stationary.

In order to reverse this order of things the rotating-magnet magneto was evolved, and owing to its many advantages it has to a large extent superseded the fixed-magnet type.

In the rotating-magnet magneto *the more delicate parts*, including the primary and secondary windings as well as the fixed condenser, *are fixed* whilst the more robust magnets revolve. The contact breaker does not rotate, so that the various fixed parts mentioned are not subjected to mechanical stress.

The principle of this type of magneto is illustrated in the case of the B.T.H. vertical magneto—referred to more fully later—in Fig. 116. In this diagram will be seen the rotating magnet ring having four poles, namely two N and two S ones, arranged alternately at equal intervals; the magnets are of aluminium-nickel-iron alloy. Only two poles are in use at any time for each ignition spark, but the whole flux of the magnet passes each time through the core carrying the armature winding above. The arrangement shown is that of the four-cylinder magneto. In the six- and eight-cylinder models there are six and eight pole pieces, respectively, instead of the four shown in Fig. 116. In each case, however, the magnets rotate at one-half engine speed to give one spark per cylinder every two revolutions.

The fixed armature consists of the primary and secondary windings, wound in opposition, one end of each coil being earthed. The primary goes to the insulated contacts of the contact breaker and also to one side of the condenser. The outer end of the secondary is connected to a spring contact which presses on a resistance unit, or pellet, the object of which is

to suppress any high-frequency current surges in the secondary circuit, as these might be liable to cause a breakdown. The magneto embodies an automatic timing advance centrifugal device.

The Lucas rotating-magnet magnetos used for four- and six-cylinder engines and their maintenance and servicing will now be described.

The construction of the magneto with its windings stationary allows almost unlimited space for the H.T. winding. This has two advantages: in the first place it permits of the provision of much more ample insulation than is otherwise possible, and in the second place it permits of a much

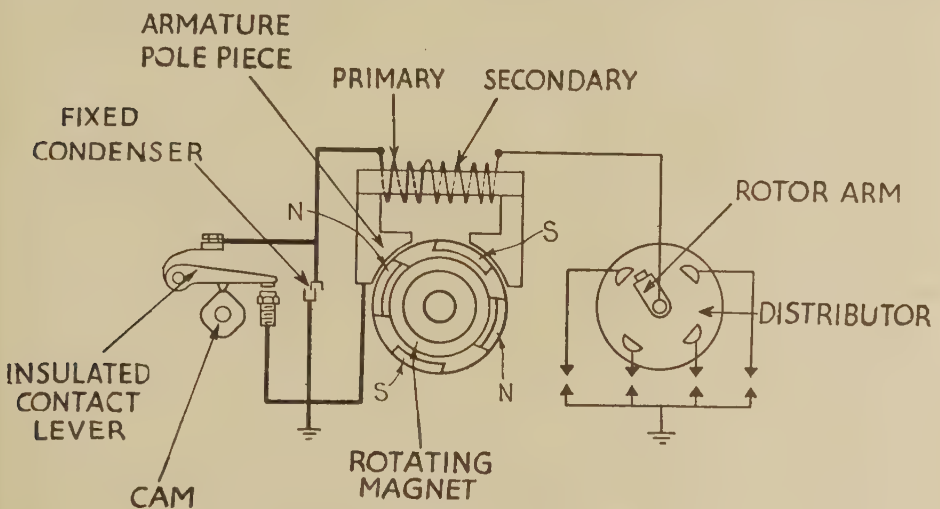


Fig. 116.—Principle of Rotating Magnet Type of Magneto. (B.T.H.)

heavier primary winding, which gives greatly improved slow-speed performance. The arrangement of the magnetic system allows this exceptionally good performance at slow speeds, without running the risk of excessive spark energy at high speeds. The armature reaction is proportioned so as to regulate the energy available at high speed and to obviate any possibility of burning away either of the sparking-plug electrodes or of the contact points.

Operation.—The operation of this magneto is based on the same general principles as the other type, viz. the rapid change of the magnetic flux in a laminated iron core carrying a suitable winding. In these magnetos the core and windings are stationary, and the reversal of the flux is obtained by the rotation of a permanent magnet. The rotor consists of a cobalt-steel magnet arranged with a pair of laminated pole pieces. It rotates between another pair of laminated pole pieces which are bridged by a laminated core, on which are wound two windings—a primary winding consisting of a few turns of relatively thick wire, and a secondary winding consisting of a large number of turns of thin wire. The contact breaker

is arranged to open circuit the primary winding at the instant a spark is required. The cycle of events in the operation of the magneto is as follows:

The engine drives the rotor and its rotation produces an alternating magnetic field in the core. This, in turn, generates an alternating L.T. current in the primary winding. At about the instant when this current reaches its maximum value, one of the lobes of the cam is timed to strike the contact-breaker lever and so separate the contacts. This causes a high-voltage current to be induced in the secondary winding, which passes to the distributor and so to the sparking plugs.

Maintenance of Rotating-magnet Type of Magneto

The Lucas rotating-magnet-type magneto requires periodical cleaning, adjustment of the contact breaker, and lubrication.

Cleaning.—Occasionally remove the distributor moulding, which is secured either by two nuts or by two screws. With machines of the brush type any carbon deposit in the distributor must be wiped away, the brush track being cleaned at the same time by means of a cloth moistened with a few drops of petrol. This brush in the rotating arm must work freely in its holder; if it is clogged, remove and clean it as well as the holder. If after long service the brush is very much worn, it may be necessary to replace it.

With machines of the jump-spark type, the inside of the distributor moulding and the distributor rotating arm must be wiped clean with a cloth moistened with a few drops of petrol. It is very important to remove all traces of deposit or other foreign matter from the inside of the distributor moulding, particularly from between the metal electrodes. Neglect to do this may result in the failure of the moulding. Care must be taken after cleaning that the distributor is quite free from petrol before replacing it on the magneto.

Before refitting the distributor, clean the outside, particularly the spaces between the high-tension leads.

Now examine the contact breaker. Swing aside the flat holding-on spring C (Fig. 117) retaining the contact-breaker cover, and then remove the cover, when the contact breaker will be exposed to view. It is essential that the contact breaker is kept spotlessly clean; above all, the contact points themselves must be free from all traces of oil. Neglect of this precaution may be the cause of misfiring.

Cleaning and Adjusting Contact Breaker.—Dirty contacts are best cleaned by polishing with fine carborundum stone, or, if this is not available, fine emery cloth may be used. Wipe away any dirt or metal dust with a cloth moistened with petrol.

To render the contacts accessible for cleaning, the contact-breaker arm can be removed by unscrewing the nut K and withdrawing the locating spring. When replacing the arm take care to fit the washer before refitting the locating spring.

Contact-breaker springs must be examined and any rust wiped away.

The gap to which the contact-breaker contacts must be set when they are fully opened is ·012 in.; a gauge of this thickness is provided on the side of the spanner supplied with the magneto. It is inadvisable to alter the setting unless the gap varies considerably from the gauge.

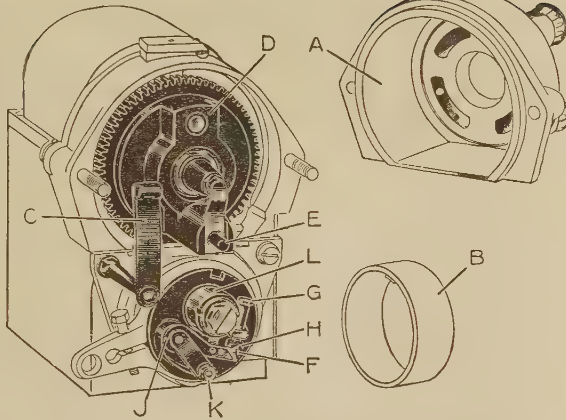


Fig. 117.—The Lucas Rotating-magnet Magneto with Contact-breaker Cover removed.

A, Distributor.
B, Contact-breaker Cover.
C, Spring securing Contact-breaker Cover.
D, Distributor Rotating Arm.
E, Carbon Brush.
F, Contacts.
G, Locking Sleeve.
H, Hexagon Head.
J, Contact-breaker Lever.
K, Nut securing Locating Spring.
L, Cam.

If the contacts need adjustment, turn the engine round by hand until the contacts are fully opened. Then slacken the locking sleeve G and rotate the contact screw by its hexagon head H until the gap is set to the thickness of the gauge. Finally tighten the locking sleeve.

Care must be taken that the gap is not appreciably greater than the standard amount, as an unduly wide opening would not only be a possible cause of misfiring, but would also be apt to cause undue wear.

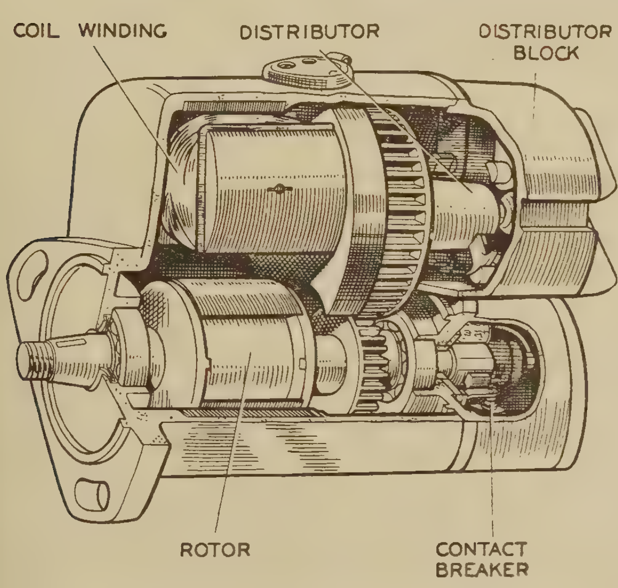


Fig. 118.—The Lucas R.F.4F. Rotating-magnet Magneto.

Timing the Magneto.—The rotating-magnet type of magneto is timed in exactly the same manner as the fixed-magnet pattern, so that the instructions given on page 115 apply equally to the magneto in question.

In the later model R.F.4F. (Fig. 118), the contact-breaker gap is also ·012 in. and the plug gap is ·020 in.

Rotating-magnet Type Magneto Troubles

The possible troubles likely to occur after long service with the Lucas Types R.F.4 and R.F.4F. rotating magnetos, together with the probable causes and remedies, are shown in a convenient form in the table below.

Condition	*Possible Causes and Methods of Detection*	*Remedy*
Engine will not fire.	Controls not set correctly for starting.	See that ignition is switched on, petrol turned on, and everything is in order for starting.
	Dirty or pitted contacts.	Clean contacts.
	Contact breaker out of adjustment. Turn engine until contacts are fully opened and test gap with gauge on screw-driver.	Adjust gap to gauge.
	High-tension cables perished or worn.	Renew cables.
Engine misfires.	Dirty or pitted contacts.	Clean contacts.
	Contact breaker out of adjustment. Turn engine until contacts are fully opened and test gap with gauge on screw-driver.	Adjust gap to gauge.
	Remove each sparking plug in turn, rest it on cylinder head and observe whether a spark occurs when engine is turned.	Clean plugs and adjust gap to about ·020 in. Replace cable if insulation shows signs of deterioration or cracking.
	Irregular sparking may be due to dirty plugs or defective high-tension cables. If sparking is regular the trouble is probably due to engine defects.	Examine carburettor, petrol supply, etc.

The C.A.V. Rotating-magnet Magneto

This modern type of magneto was designed to suit the exacting conditions of high-speed commercial petrol-engine ignition. It is of the rotating-magnet pattern, whereby the magnet system revolves whilst the less robust items, such as the windings and condenser, are stationary; the contact breaker is also fixed.

The magneto can operate at high speeds continuously with reliability and gives easy starting under all normal conditions. It has an ample ignition range and is available with both hand and automatic advance control or with the latter system of control only. The combined ignition advance range is 40° and 60° for the four- and six-cylinder magneto, respectively, as measured on the rotor shaft.

The contact breaker and distributor form a separate unit, which is driven from the magneto shaft by spiral gearing. The rotor and the gears driving the contact breaker and distributor shaft run on ball bearings of the grease-packed pattern, *requiring no oiling*. The contact breaker is operated by a four- or six-lobed cam for the four- and six-cylinder models,

respectively, so that the distributor and contact-breaker shaft *are driven at one-half* engine speed only.

The contact breaker incorporates an exceptionally light lever capable of operating up to the highest speeds without risk of "*flinging*." Owing to its outstanding low inertia, there is no danger of the contact points becoming hammered out, becoming loose or mechanically damaged at high speeds. Wear of the contact-breaker parts is negligible and consequently adjustment will very rarely be necessary owing to the comparatively low cam speed and the adequate design of the contact breaker.

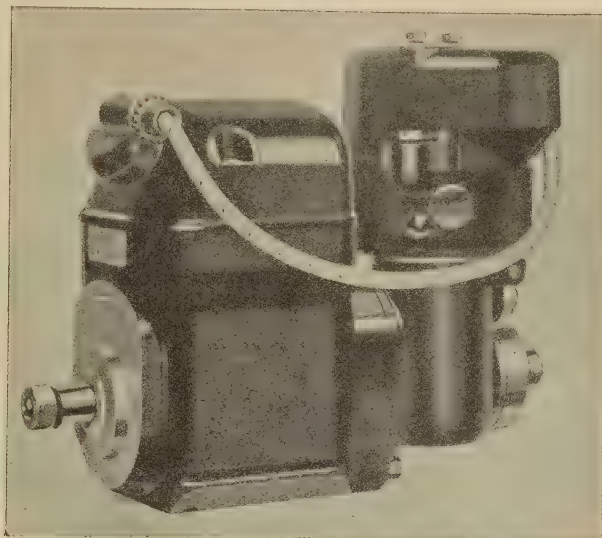


Fig. 119.—The C.A.V. Rotating-magnet Magneto, Type BJR.

The operation of the magneto depends upon the rapid reversal of the magnetic flux in a laminated iron core carrying a suitable winding. The core and windings are stationary and the reversal of flux is obtained by the rotation of a permanent magnet. The rotor is a cobalt-steel magnet with a pair of laminated pole pieces. It rotates between another pair of laminated pole pieces, which are bridged by a laminated core, on which are wound two windings, viz. a primary winding of a few turns of relatively thick wire and a secondary winding consisting of a large number of turns of fine wire. The contact breaker is arranged to open-circuit the primary winding at the instant a spark is required at the sparking plugs. The engine drives the rotor and its rotation produces an alternating magnetic field in the core. This, in turn, generates an alternating L.T. current in the primary winding. At the instant when sufficient electro-magnetic energy is stored in the primary winding, one of the lobes of the cam F (Fig. 120) is timed to strike the contact lever E and thus open the contact points D. This causes a high voltage to be induced in the secondary winding when the high-voltage spark occurs at the sparking plug, via the terminal M to the carbon brush N in the centre of the distributor moulding. This brush makes contact with the rotating distributor arm H and the current passes from here to one of the metal inserts B in the distributor moulding which in turn is connected by H.T. cable to one of the sparking plugs.

Timing the Magneto (C.A.V.).—The following is the procedure for

timing the type BJR magneto previously described and illustrated in Figs. 120, 121, and 122. The timing operation consists of adjusting the angular relation between the magneto spindle and the driving spindle geared to the engine.

(1) First check that the cables from the sparking plugs are connected in correct firing order to the distributor. Also see that the direction of rotation of the magneto as marked on the driving end plate corresponds to the direction of rotation of the engine driving shaft for the magneto.

(2) Revolve the engine crankshaft by hand until No. 1 piston is on its compression stroke and is in the timing position recommended in the

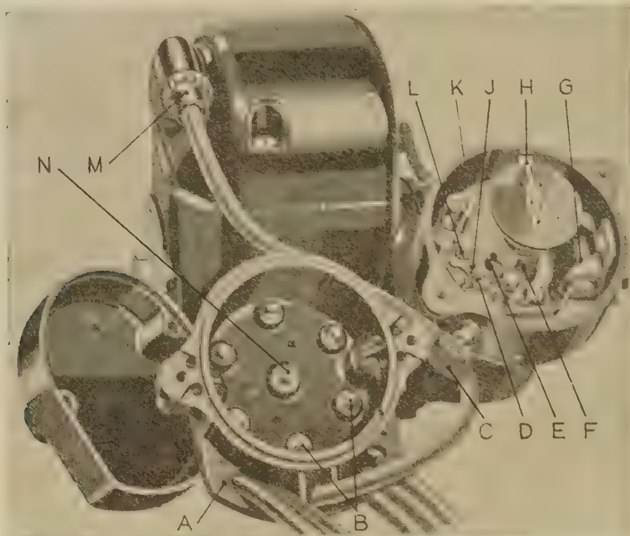


Fig. 120.—The C.A.V. Type BJR Magneto.

A, Distributor Moulding.
B, Metal Inserts.
C, Short-circuiting Terminal.
D, Contacts.
E, Lever.
F, Cam.
G, Condenser.
H, Metal Electrode.
J, Locking Screw.
K, Timing Mark.
L, Adjustment Screw.
M, High-tension Terminal.
N, Carbon Brush.

engine manufacturer's handbook. Most vehicles have a timing mark on the flywheel which gives the firing position when the ignition is fully retarded, and it is therefore important to observe that the hand-timing lever for the magneto is in the full-retard position.

(3) Slacken the magneto-coupling securing nuts on the armature spindle, or any other screws, as necessary, to enable the magneto spindle to be turned independently of the engine.

(4) Remove the distributor moulding and turn the magneto spindle until the distributorarm electrode H is pointing at the red mark K on the side of the distributor body. This gives rough adjustment.

(5) Slightly turn the armature just sufficiently to separate the contact

points D. The moment of separating is best determined by inserting a steel strip about ·001 in. thick between the contacts. The moment at which the strip can be withdrawn is the moment at which the contacts open. This position is the firing-point and the magnet drive should be permanently fixed in this position.

(6) It is always advisable to check the timing after tightening up, to ensure that no movement has taken place.

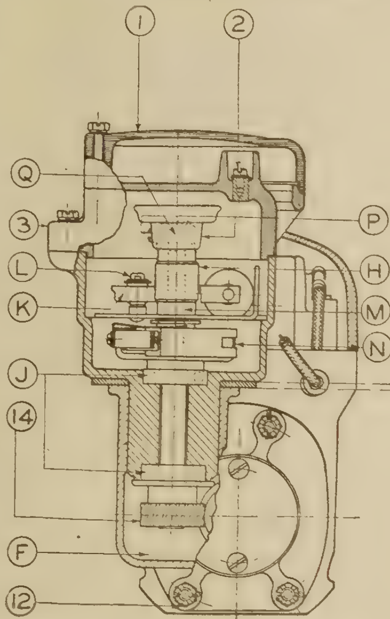


Fig. 121.—Timing and Servicing the C.A.V. Magneto.

Dismantling the Magneto.—The following notes should be read in conjunction with the diagrams given in Figs. 121 and 122. The dismantling procedure is as follows:

Remove the distributor cover, No. 1.

Remove screws No. 2, holding H.T. cables.

Remove distributor body, No. 3.

Unscrew cable, No. 4, inside distributor housing.

Unscrew the hexagon screw, No. 5, which holds distributor housing and remove distributor complete.

Never alter the position of the two timing screws (No. 21). If these are moved in any way, it will be necessary to retime the magneto itself.

Remove top cover of magnet, No. 6.

Remove the H.T. terminal, No. 7, on magneto cover.

Remove the armature and magnetic shunt, No. 8.

Remove hexagon screw, No. 9, in centre of advance lever.

Unscrew the three countersunk screws, No. 10, on the stop ring for advance lever. Remove the regulating screw complete with end cover.

Remove worm wheel, No. 11, with ball-race and coil spring from the rear spindle of the rotor.

Remove split-pins and unscrew the three hexagon nuts, No. 12, holding the distributor bracket, and remove same.

Remove the rotor, No. 13.

Clean all parts.

Reassembling and Greasing Magneto.—Fill both ball-races A of the rotor with grease.

Assemble the rotor, No. 13, with the housing. Allowable end play is ·004 in. to ·008 in.

Assemble the distributor bracket and replace the three hexagon nuts, No. 12, locking them with split-pins.

Insert coil spring into recess in the rear spindle of the rotor.

Smear splines on rear of rotor spindle, spring, worm, and ball-race D with grease.

Replace worm, No. 11, with ball-race on the rotor shaft.

Smear regulating screw E and fill recess with grease; insert regulating screw in nut. *Note.*—The lubricating slot on the shoulder of the nut must correspond with the hole in the regulating screw.

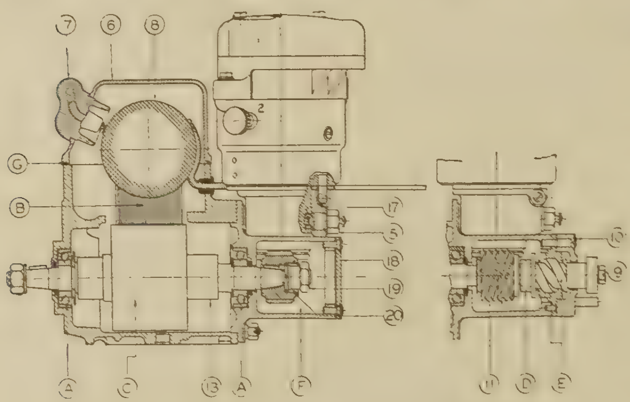


Fig. 122.—Dismantling the C.A.V. Magneto.

Assemble stop ring with pin for advance lever on the spigot of the nut. Fix advance lever by hexagon-headed screw, No. 9.

Fix stop ring and nut to distributor bracket with three countersunk screws, No. 10. The lubricating slot in the nut must always point upwards.

Fill the vertical distributor-bearing housing F with approximately 1 oz. of grease for lubricating the worm wheels, also smear all sliding surfaces.

When reassembling the same components into a given magneto, no retiming of the magneto should be necessary. Care in assembling must be taken to see that the centre line of the keyway in the magneto spindle is in line with the white mark on the magneto body, and when inserting the distributor, see that the electrode lines up with the red mark on the distributor housing. This should bring the stop pin up against the yellow-painted adjusting screw. This is in the case of column-control magnetos. With magnetos with axial control, the pin should fit snugly between the two adjusting screws with the timing lever in its free position, i.e. fully advanced.

When for any reason it has been found necessary to fit new parts such as a distributor, shaft gears, or contact breaker, then retiming of the magneto is necessary.

On magnetos with automatic timing only, the same applies as with axial magnetos, but of course no hand-timing lever exists.

Grease the packing G in the groove of the magneto cover.

Fix H.T. terminal, No. 7, to magneto cover.

After refitting magnetic shunt and armature, replace magneto cover, No. 6.

Note.—When correctly fitted it should be possible to feel the pressure of the spring in the H.T. terminal on the contact strip of the armature.

The Distributor.—*Before dismantling the distributor* particular attention *must* be paid to the position of the marked tooth on the brass cheek of the

gear (14) relative to the fixing hole in the cam bush for the H.T. rotor, as a reassembly of the gear in the wrong position, i.e. 180°, will materially affect the timing. This only applies to six-cylinder magnetos.

Trouble Location and Remedies

Condition	*Possible Cause*	*Remedy*
	Short-circuiting cable earthed. Remove cable from terminal on magneto or from switch and endeavour to start engine again.	Renew short-circuiting cable.
Engine stops suddenly or will not fire.	Remove sparking plugs and place them on engine and observe whether sparks occur when engine is turned.	
	If the sparks do not jump across the electrodes, hold the cable ends at a distance of about ⅛ in. from the engine while engine is turned over.	
	If sparks jump the gap, the sparking plug is at fault.	Clean the sparking plug or replace with new plug.
	If sparks do not jump the gap, inspect contact-breaker points to see whether they are dirty or worn. It is possible that the H.T. cables have been damaged or that they have become loose.	The contact-breaker points should be cleaned and if necessary adjusted or replaced, and H.T. cables replaced or terminals tightened.
Uneven running of the engine.	*Engine becomes hot, and does not accelerate.* Ignition retarded too much, magneto incorrectly timed, or coupling loose.	Advance ignition. Retime magneto.
	Engine "knocks." Ignition advanced too much, magneto incorrectly timed, or coupling loose.	Retard ignition. Retime magneto.
	Stopping. Short-circuiting cable earthed.	Renew the cable.
	Sparking plug oiled up or fouled or out of adjustment.	Clean plugs and adjust to correct setting.
	Contact-breaker contacts dirty or worn.	Clean and adjust contacts and if necessary replace.
	H.T. cables loose or damaged.	Tighten terminals or fit new cable.
	Explosions in the carburettor. Firing by incandescence through the plugs having become too hot.	Use plugs recommended by engine makers. See that they are screwed in tightly, and that packing rings have not been forgotten.
	Firing by incandescence can also be produced by oil carbon on the plug or in cylinder.	Clean plug and prevent it being oiled up.
Engine fails to start after refitting magneto.	*If sparks do occur*, either *H.T. cables are confused* or damaged, the magneto has been wrongly timed, or the gap between the plug electrodes is too large.	Connect H.T. cable correctly change damaged cable, retime magneto, or adjust sparking-plug gaps.

The fibre cam H must be coated with grease ·2 mm. to ·3 mm. thick. Both ball-races J on the distributor spindle must be filled with grease.

All blue contact-breaker springs K to be greased lightly.

All bright springs need not be greased.

Lubricate the contact-breaker lever pin L with grease.

It should be noted that the H.T. rotor must be firmly fixed with its screw P.

The gap between the contacts must be adjusted by means of the eccentric screw and *set to* ·3 mm. to ·4 mm.

When the distributor has been mounted in its bearing bracket, locate the plunger of the hexagon screw in the hole in the brass segment, No. 17.

Fasten distributor with the hexagon screw, No. 5.

Connect cable, No. 4, to terminal inside distributor.

Fix distributor body, No. 3.

It should be noted that magnetising jaws must be pressed on to the visible faces of the pole shoes when magnetising, and that *the keyway on the rotor spindle must be horizontal during this operation.*

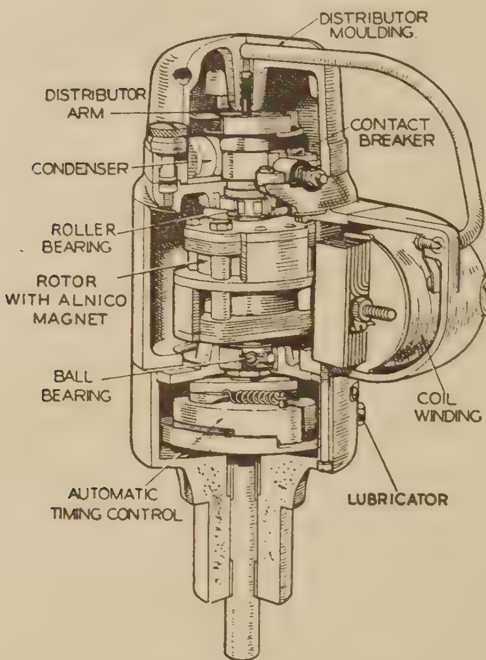


Fig. 123.—The Lucas Vertical Type Camshaft Magneto (Model 4VRA) with Automatic Timing Control.

Camshaft-pattern Magnetos

A more modern development of the magneto is the camshaft pattern mounted vertically and driven in the same manner as the contact breaker and distributor unit of a coil-ignition system. Typical examples of such magnetos are the Lucas four- and six-cylinder patterns and the Scintilla.

The following are the more important features of these camshaft magnetos, with special reference to the Lucas types, for four- and six-cylinder engines, respectively:

(1) The design is of the rotating-magnet type, i.e. the magnet system revolves while the less robust parts such as windings and condenser are stationary.

(2) The magnet and pole system is arranged so that the number of sparks produced for each revolution of the magnet rotor is equal to the number of engine cylinders for which it is intended.

The drive for the unit is half-engine speed, exactly as for a coil-ignition distributor.

(3) The rotor, which is carried on two ball bearings, is built up with a single circular magnet and four or six laminated pole shoes according to the type of machine.

The magnet is made of Alnico, a special nickel-aluminium-iron alloy, which has been developed and is fabricated in the Lucas works. This material has better magnetic properties than cobalt-steel alloys, and is particularly resistant to demagnetisation.

(4) The contact breaker is of standard design as used on coil-ignition distributors, so as to facilitate the servicing of these machines.

(5) The drive is taken through the automatic advance and retard mechanism to the rotor, at the one end of which is the contact-breaker cam. The contact breaker and distributor are mounted in the same manner as for coil-ignition equipment.

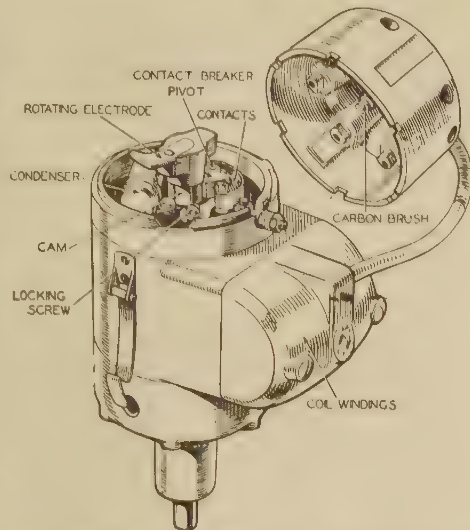


Fig. 124.—The Lucas Magneto, with Distributor Moulding removed.

The advantage of this scheme is that no gearing is interposed between the rotor shaft and the contact breaker and distributor portion of the machine.

(6) The automatic-advance mechanism housed in the lower part of the body between the rotor and the driving shaft is of the centrifugal type with an auxiliary weight coupled to the main weight. It is arranged so that at low speeds the auxiliary weight acts with the main weight, and at high speeds against it. By this means the weights can be arranged to give a timing curve of any desired characteristic likely to be required. The mechanism is designed to be self-locking, so that there is no possibility of any rattling at low speeds.

(7) These machines give an exceptionally good performance at slow speeds and function satisfactorily at all speeds up to 10,000 engine r.p.m.

Adjustment and Maintenance.—The only adjustment necessary is that of the contact-breaker gap and the timing.

The contact-breaker gap is carefully set before leaving the Lucas Works, and a gauge is provided with each magneto.

Provided that the cam is kept clean and that the instructions on cam lubrication are carried out, the wear on the fibre heel will be negligible, and consequently the contact-breaker gap will only need adjustment at long intervals.

To test the contact-breaker gap, turn the engine over by hand until the contacts are seen to be fully opened. Now insert the gauge on the screw-driver in the gap; if it is correct, the gauge should be a sliding fit. It is not advisable to alter the setting unless the gap varies considerably from the gauge. If adjustment is necessary, proceed as follows: When the contacts are fully opened, slacken the two screws in the contact plate and adjust the plate until the contacts are set to the gauge. Finally tighten the two screws.

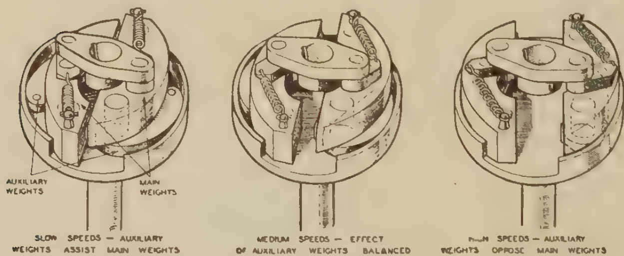


Fig. 125.—The Automatic-advance Mechanism of the Lucas Vertical Magneto.

Cleaning Instructions.—Occasionally remove the distributor moulding by pushing aside its two securing springs. See that the electrodes are clean and free from deposit. If necessary, wipe out the distributor with a dry duster, and clean the electrodes with a cloth moistened with petrol. See that the carbon brush is clean and moves freely in its holder. Clean the outside of the moulding, particularly the spaces between the terminals.

Next examine the contact breaker; it is important that the contacts are clean and free from oil or grease. If they are burned or blackened, they may be cleaned with very fine carborundum stone or emery cloth, and afterwards wiped with a cloth moistened with petrol. Care must be taken that all particles of dirt and metal dust are wiped away. Misfiring may be caused if the contacts are not kept clean.

Lubrication Attention.—The following are instructions for lubricating the magneto-shaft bearing, cam of contact breaker, and the contact-breaker pivot bearing:

(1) *Magneto Shaft.*—Add one or two drops of thin machine oil to lubricator every 1,000 miles.

(2) *Cam.*—About every 3,000 miles give the cam the slightest smear of vaseline.

(3) *Contact-breaker Pivot.*—Every 5,000 miles, place a single spot of thin machine oil on the pivot on which the contact-breaker lever works.

Timing the Camshaft Magneto

The magneto is usually carried in a clip attached to the timing lever. The timing can be adjusted by loosening the clamping screw on the clip and turning the magneto in the desired direction. The contact-breaker heel is thus moved round the cam, and so the positions of firing are altered.

Before removing the magneto from the engine for any reason, it is advisable to mark the position of the magneto body, lever, and rotating arm so that the magneto can be replaced in the same position and so avoid retiming.

Whenever possible, follow the car manufacturer's instructions for timing, as the best position will vary according to the characteristics of the particular make of engine.

Where detail instructions are not available, the following general procedure for timing or checking the timing can be followed:

(1) Turn the engine over until No. 1 piston is at the top of its compression stroke (that is, on top dead centre). On most engines this position is indicated by a mark on the flywheel.

(2) About half retard the hand-ignition control (when fitted).

(3) With the engine and the control set in the above positions, the timing is correct if the contacts are just commencing to separate and the metal electrode on the rotating distributor arm is pointing to the insert in the moulding connected to plug No. 1. If necessary slacken the clamping screw on the timing lever and turn the magneto until this position is found. After setting the magneto, tighten the clip.

It should be seen that the plugs are connected to the magneto in sequence according to the firing order of the engine.

4. If, on running the engine, the firing is found to be slightly too early or too late, this may be corrected by again slackening the clamping screw and turning the magneto a fraction in the required direction, afterwards tightening the clamping clip.

Possible Faults and Remedies of Camshaft Magnetos

If a failure of ignition occurs, unless the cause is at once apparent it is recommended that the procedure given in the table on page 130 is followed; this should enable the trouble to be quickly located.

Before proceeding with the examination, it must be checked that the trouble is not due to defects in engine, carburettor, petrol supply, sparking plugs, etc.

If misfiring occurs in only one cylinder, either the plug lead or the plug may be at fault. An examination of the H.T. cables may reveal the fault; the rubber may show signs of perishing or cracking; it will not last for ever. If a spare plug is available it may be substituted for the suspected one, or if it is merely the gap that is too large, it may be adjusted. Missing with full throttle is sometimes due to the plug gaps being too wide. Bad plug insulation is sometimes caused through sooting, and may occasionally be remedied by washing the plug out with petrol. It is sometimes recommended to remove the plug and, allowing the body to rest on the cylinder head, to observe whether a spark occurs at the points when the engine is turned by hand. It should, however, be noted that this is only a rough test, since it is possible that *a spark may not occur when the plug is*

under compression. If it is suspected that the ignition has failed completely in all cylinders, this may be checked by removing from the plug terminals one or more of the H.T. cables and observing whether a spark occurs on turning the engine round at not less than 50 r.p.m. with the terminal lead held about $\frac{1}{8}$ in. from some metal part of the engine. If no spark

CAMSHAFT-MAGNETO FAULTS AND REMEDIES

Condition	*Method of Detection of Possible Causes*	*Remedy*
Engine will not fire.	Controls not set correctly for starting.	See that ignition is switched on, petrol turned on, and everything is in order for starting.
	Dirty or pitted contacts.	Clean contacts.
	Contact-breaker contacts out of adjustment. Turn engine until contacts are fully opened and test gap with gauge on screw-driver.	Adjust gap to gauge.
	H.T. leads perished or worn.	Renew cables.
Engine misfires.	Dirty or pitted contact points.	Clean contacts.
	Contact-breaker points out of adjustment. Turn engine until contacts are fully opened and test gap with gauge on screw-driver.	Adjust gap to gauge.
	Remove each sparking plug in turn, rest it on the cylinder head and observe whether a spark occurs at points when engine is turned.	Clean plugs and adjust the gaps to about ·020 in.
	Irregular sparking may be due to dirty plugs or defective H.T. cables. If sparking is regular at all plugs, the trouble is probably due to engine defects.	Replace any lead if the insulation shows signs of deterioration or cracking. Examine carburettor, petrol supply, etc.

[*J. Lucas Ltd.*

takes place, examine first the earth wire leading from the magneto to the cut-off switch; it may have been accidentally earthed. This may be proved by temporarily disconnecting the earth wire from the terminal on the side of the magneto. If the magneto has been removed and then replaced, it is possible that it may have been timed incorrectly; the timing should then be checked over, following the instructions previously given.

The B.T.H. Vertical Magneto

Known as the B.T.H., Type J unit, this magneto is of the rotating-magnet pattern, incorporating an automatic timing mechanism operating in an oil bath. These magnetos are made in the Types J and JD models and include the J4 Form T4, which is used to replace the coil-ignition units of the Ford 8- and 10-h.p. engines; and the Type J8 Form S for the 30-h.p. Ford V-8 engine. The magneto is made to be interchangeable with the standard coil-ignition distributor head, and it can therefore readily be

substituted for the latter. The main housing is an aluminium die casting having laminated armature poles formed integrally. The armature windings are screwed to the poles and so arranged that removal and replacement can be effected without further dismantling of the magneto. The windings are enclosed by a water- and dust-proof Fabrolite cover; connection between the distributor head and the secondary winding is made by means of a H.T. lead secured to a spring contact within the cover. The rotating magnet assembly is mounted on a shaft running in ball bearings.

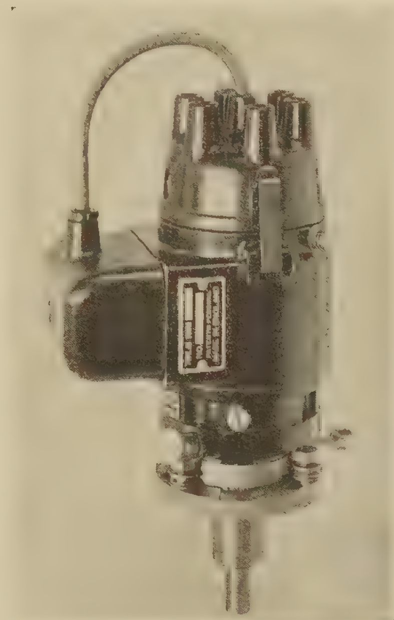


Fig. 126.—The B.T.H. Vertical Magneto (Type J6).

A four- and six-lobe cam, lubricated by a felt pad, is fitted to the upper end of the shaft, while a driving plate at the lower end engages with the automatic timing mechanism.

The contact-breaker mechanism incorporates a pressed-metal contact lever operated by the rotating cam through a fibre heel. The contact lever is insulated from the housing; the control spring and a phosphor-bronze conducting strip being taken to an insulated terminal for the magneto cut-out circuit. A tubular paper condenser is clamped to the housing and connected directly across the contacts, which are of iridium-platinum alloy.

The distributor is similar to that used for coil-ignition equipments, the distributor brush being located on an extension to the rotating cam.

The automatic timing mechanism is enclosed in the lower end of the housing in an oil bath with leather seals to prevent oil leakage. Two filling screws are provided. The design is similar in principle to the standard governor mechanism, but the weights are heavier, due to the greater inertia of the rotating parts.

Timing the B.T.H. Vertical Magneto.—The ignition timing will vary for different engines, but in the absence of precise instructions from the engine makers the following general instructions can be used. Subsequent minor adjustment can easily be made if it is found that the ignition appears to be either too advanced or too retarded.

The automatic timing mechanism normally provides an automatic timing range of 25° on the engine crankshaft. Therefore it is necessary to make allowance for this when timing the magneto on the engine.

(1) Slacken the timing-lever clamping screw.

(2) Turn the engine until the piston of No. 1 cylinder is at the top of its compression stroke.

(3) Move the ignition-control lever at the driver's seat to full advance and then retard it 5° to 10°.

(4) Remove distributor moulding from the magneto.

(5) Turn the slotted clamping plate in the opposite direction to the magneto-spindle rotation until the ends of the slots are within 2 mm. of the studs; that is, just short of the full-advance position.

(6) With the clamping plate held in this position, turn the magneto on its seating so that the contact-lever heel approaches the leading edge of the cam lobe and until the contacts *just separate.*

(7) Without moving either the magneto or the clamping plate, move the timing lever to the desired position for connection to the control rod.

(8) Tighten timing-lever clamping screw and attach the control rod.

(9) Replace distributor moulding and connect No. 1 cylinder plug lead to the distributor terminal adjacent to the rotating distributor electrode.

(10) Connect up other terminals of the distributor, in the order the distributor electrode passes them when rotating, to the remaining cylinders according to their firing sequence.

Note.—The above instructions provide for a fully advanced ignition timing (including automatic timing control) of 30° on the engine crankshaft before the piston reaches the top of its compression stroke.

Maintenance of B.T.H. Vertical Magnetos.—*Immediately after installation and every* 500 *miles, or* 20–30 *hours' running*, give one turn to the driving-spindle grease cup. When necessary replenish this cup with good-quality grease, such as Price's Belmoline "C." In some cases a self-lubricating bearing is used, so that no grease cup is provided.

Every 2,000 *to* 3,000 *miles, or* 30–50 *hours' running*, lubricate the contact-lever bearing and cam-lubricating pad. Two drops of light machine oil will generally be adequate on each occasion. Excess of oil should be avoided and any surplus oil should be wiped away, otherwise it may reach the contacts.

Every 5,000 *miles, or* 100 *hours' running:*

(1) Check the gap between the contacts. If necessary, adjust to ·018 in. or to gauge attached to spanner provided. At the same time clean the inside of the distributor moulding, also the distributor electrode holder, free from oil or dust deposit.

(2) Remove *both* plug screws from oil filling holes in the automatic timing mechanism and add ½ oz. (14 gms.) of Vacuum Oil Co.'s cylinder oil EF 212. Good-quality oil, such as Mobiloil "BB," may be used as an alternative. Allow a few minutes for any surplus oil to overflow before replacing the plug screws.

Periodically, particularly after washing down the car, wipe the outsides of the distributor and winding cover mouldings free from dust, dirt, or moisture.

Diagnosing Troubles.—If any trouble occurs it is advisable to make sure that the ignition system is actually at fault before making any adjustments.

Misfiring (Magneto) :

(1) Examine the contact breaker; the gap should be ·018 in. and the points clean. Also check that the contact-breaker lever movement is quite free.

(2) Examine the sparking plugs and check their gaps which should be set between ·018 in. and ·025 in. wide. If the plugs have been in service a long time, they may require cleaning or replacing.

(3) Examine the H.T. cables for perished or chafed insulation.

(4) Examine inside of distributor for dirt or deposit.

(5) Remove short-circuiting lead from magneto to ascertain whether abrasion or chafing of this lead causes intermittent short-circuiting to some part of the frame.

Inspection and Servicing of J-type Magnetos

The various maintenance, inspection, and servicing instructions for the B.T.H. types J and JD magnetos are illustrated in Fig. 127. The drawings also indicate where special tools are to be employed. It is important when dismantling these magnetos to observe how the components are related so that they can be reassembled in the same manner.

In particular, the relationship between the distributor, brush holder, and the driving dog should be carefully noted (Fig. 128).

Method of Timing the Rotor and Cam.—If the rotor or cam has to be removed from the magneto it will be necessary to retime the rotor and cam in the correct relationship to the housing poles and contact breaker. Gauge No. 15478 should be used for this purpose (Fig. 128, left).

The gauge is in two parts—a graduated ring member, and a pointer member—and the timing operation, which should be carried out before fitting the automatic timing governor and spindle housing, is as follows:

(1) Turn the rotor to a locked magnetic position, i.e. when the rotor poles are bridging the housing poles.

(2) Fit the graduated ring member accurately on the distributor spigot of the main housing. The distributor locating pin in the housing locates in a slot in the ring member.

(3) Fit the pointer member on to the magneto cam, locating it in the slot in the cam.

(4) Holding the rotor in the locked magnetic position, turn the cam in the direction of rotation until the contacts just separate (a lamp and battery should be used to determine when the contacts open).

(5) With the cam in this position, note the degree reading on the graduated ring opposite the pointer.

(6) Now turn the cam back 8° to 10°, i.e. in a direction opposite to rotation.

(7) Hold the cam in this position whilst screwing down the cam-fixing screw.

(8) If the cam has not been disturbed in tightening the fixing screw, knock down the rim of the locking collar into the slot in the cam.

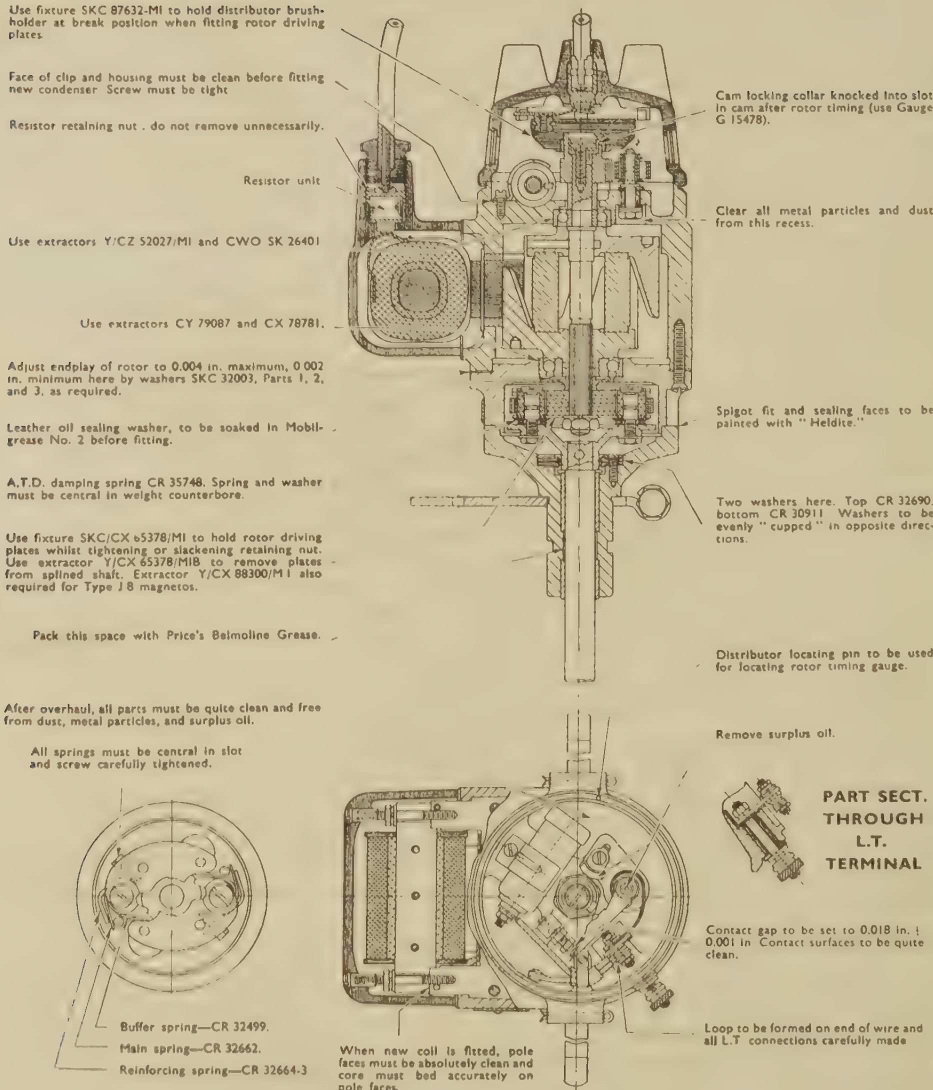


Fig. 127.—Maintenance and Servicing Instructions for B.T.H. Vertical Magnetos.

(9) Re-check the angle, remove the pointer, and fit the distributing brush holder.

Vertical Magneto Ignition Switch

It is important to remember that in no circumstances should an ordinary coil-ignition cut-out switch be used when a vertical magneto is fitted in place of the distributor and contact-breaker unit. A new magneto-

pattern switch must be used. This " earths " the live side of the primary coil and thus prevents any L.T. current from being generated.

The Scintilla Vertex Magneto

This vertical type of magneto, made by Messrs. Scintilla, Ltd., London, N.W.9, operates upon the rotating-magnet principle and it is interchangeable with distributor units of standard coil-ignition systems.

It incorporates automatic spark advance and produces a good and regular spark over a range from a low speed corresponding to 60 to 70

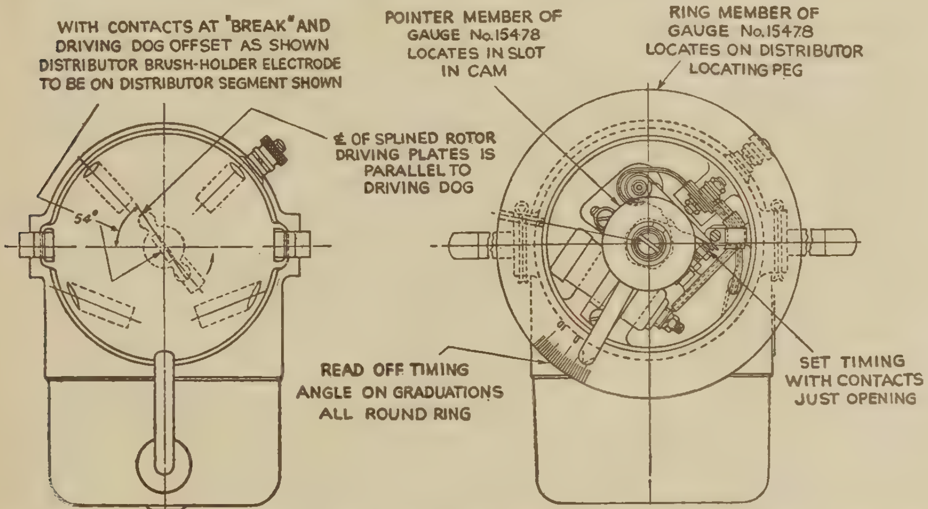


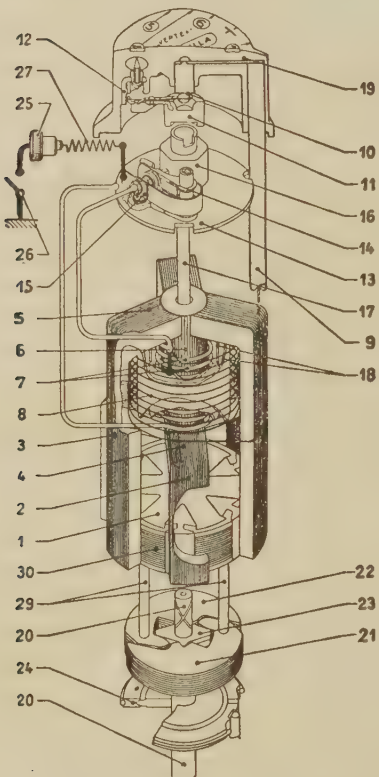
Fig. 128.—(Left) The Gauge No. 15478 used for timing Rotor and Cam on B.T.H. Types J and JD Magnetos. (Right) Distributor Brush Holder and Driving Dog Relationship on Type J4, Form T4 Magnetos on Ford 8-h.p. and 10-h.p. Engines.

r.p.m., up to the highest engine speeds; it runs at camshaft speed. Its method of operation (Fig. 129) is as follows:

The rotating permanent magnet 1, which is made of cobalt steel, produces an alternating magnetic flux in the pole shoes 2–3, and the circuit is closed through the core-connecting pieces 4–5. This alternating flux flows through the core of the coil 6 and induces a L.T. current in the primary winding 7. The sudden interruption of the primary current caused by the opening of the contact-breaker points induces a H.T. current in the secondary winding 8 which is transmitted by the H.T. distributor lead 9 to the central contact 10 of the distributor head 19. From the distributor rotor 11 the H.T. current passes through the electrodes 12 to the H.T. leads and subsequently to the plugs.

The contact-breaker assembly is mounted on a base plate 13, and consists of a rocker arm 14 and fixed contact-point carrier 15. This assembly is located in the top part of the housing and is readily accessible for inspection. The cam 16 is fitted to the rotor spindle 17, projects through

the contact-breaker base plate, and is surrounded by an oil-protection housing, the latter being provided with a felt wick for lubricating the cam. The condenser 18, connected in parallel with the contact points, eliminates sparking and burning of the points. This condenser, as on the Scintilla armatures, is placed between the primary winding 7 and the secondary winding 8, and therefore is not affected by any external influence. The



1, Rotating Permanent Magnet.
2, Short Pole Shoe.
3, Long Pole Shoe.
4, Core-connecting Piece.
5, Core-connecting Piece.
6, Armature Core.
7, Primary Winding.
8, Secondary Winding.
9, H.T. Distributor Lead.
10, Central Contact in Distributor Head.
11, Distributor Rotor.
12, Electrodes in Distributor Head.
13, Contact-breaker Base Plate.
14, Contact-breaker Rocker Arm.
15, Fixed Contact-point Carrier.
16. Cam.
17, Rotor Spindle.
18, Condenser.
19, Distributor Head.
20, Driving Spindle with Brake.
21, 22, Centrifugal Weights for the Automatic Advance Mechanism.
23, Cam for the Automatic Advance Mechanism.
24, Friction Brake.
25, Primary Terminal.
26, Ignition Switch.
27, Resistance.
29, Guide Pins for Centrifugal Weights.
30. Laminated Rotor.

Fig. 129.—The Scintilla Vertex Magneto.

distributor head 19 is firmly held in position by two accessible screws and renders the whole unit dust- and water-proof.

The permanent magnet, together with the automatic advance mechanism, rotates on the bearing of the driving spindle 20. This construction gives the apparatus greater stability.

The poles of the 4-, 6-, 8-, and 12-pole rotors are polarised alternately. Due to judicious design and by using a special cobalt steel, it has been possible to keep the dimensions of the rotor exceedingly small. The weight of this rotor is only 12 oz. and the result is obviously a very small moment of inertia.

The automatic advance device is based on an entirely new principle

and no springs are employed. The two packs of centrifugal weights 21–22 consist of laminations of various shapes and weights. Due to centrifugal force, these weights tend to move outwards, and as their movement is checked by the special cam on the driving spindle, the contact-breaker cam, which is firmly secured to the rotor spindle, automatically advances. As the speed increases, the respective centrifugal weights reach the limit of their travel and are put out of action. Consequently, any desired curve can be obtained by varying the shape and the weight of these plates. This construction has a great advantage over the more usual system of governor springs, inasmuch as the range of advance always remains constant, not being affected by fatigued springs.

Short-circuiting Arrangement.—The primary or short-circuiting terminal 25 fitted at the side of the carcase is connected to the ignition switch 26 on the dashboard. A resistance 27 is fitted between the primary terminal 25 and the primary winding 7, thus obviating any possibility of demagnetisation of the magnet if battery current should accidentally pass to the magneto.

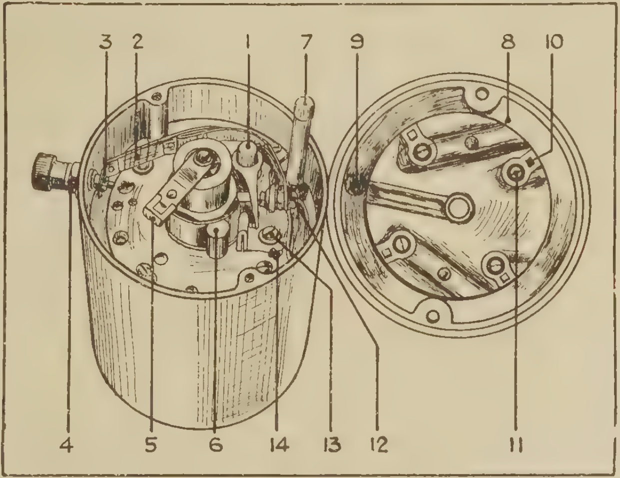


Fig. 130.—Scintilla Vertex Magneto Contact-breaker Assembly.

Timing Adjustment.—Take hold of carcase of Vertex and turn bodily in direction of arrow on distributor head 8 to retard, or in opposite direction to advance. A movement of $\frac{1}{8}$ in. measured on perimeter of carcase (where diameter is $3\frac{1}{2}$ in.) represents 4° of timing, i.e. 8° if measured on flywheel. Timing usually requires adjustment after road test. Make sure that clamping screws on timing lever are tight after timing magneto.

Contact-breaker points must be perfectly clean. Only a thin smooth file may be used for cleaning purposes, and contact faces must afterwards be flat and square. Dirty points are short-lived and cause misfiring. The usual cause is over-lubrication of cam felt 6 (Fig. 130) and rocker-arm felt 1. *Adjust* gap by turning engine till points fully open, slackening screw 13, inserting screw-driver blade in slot 14 and turning in order to move fixed contact until correct gap is obtained. Gap must be ·012 to ·016 in. (·3 to ·4 mm.). It is impossible to disturb correct bedding of contact faces when adjusting or replacing.

To replace with new contact points, remove nut and washers 3 and screw 13. Withdraw complete contact-breaker assembly. Remove screw assembly 12 and fit to new contact breaker, assembling in exactly same order as before removal. Slip new contact breaker into position and refix nut and washer 3 and screw 13. Adjust gap in line with preceding instructions.

Lubrication of spindle is by screw greaser at base of Vertex. Every 5,000 miles this greaser must be filled and screwed home three times, using Scintilla No. 934 grease. *Cam felt* 6 and *rocker arm felt* 1 must receive a slight smear only of high-melting-point grease (excess grease is thrown on to contact-breaker points). Do not use oil. *Driving gears* not automatically lubricated must be lubricated with Scintilla No. 224 grease, and this grease must be replenished every 3,000 to 4,000 miles. Both under- and over-lubrication must be avoided. Scintilla greases No. 224 and No. 934 are supplied in small quantities, conveniently packed in collapsible tubes. The fibre bush (1) must be filled with high-melting-point grease to lubricate the rocker-arm bearing pin.

The *distributor rotor* when replaced must sit firmly on the cam; there must be no clearance whatever between these two units.

If the Vertex magneto is fitted with an external condenser, make sure that the nut holding it is tight and also that the connecting strip is not touching any earthed parts.

Scintilla Magneto Fault Location and Correction

Bad Idling Speed and Loss of Power.—Test spark by disconnecting H.T. cable from sparking plug No. 1 and holding at distance of $\frac{1}{4}$ in. from cylinder block when starter is turning engine at approximately 150 r.p.m.

Regular and normal spark indicates Vertex is in order. Further procedure is:

(1) Remove plugs. Clean thoroughly and adjust gaps to ·015 in. (·4 to ·5 mm.). Test plugs if possible under compression or connect same to H.T. cables and place on engine. Turn engine by self starter. If no spark appears on plug, it is faulty and must be replaced. (It is possible that plugs break down only under compression.)

(2) Check ignition timing. Adjust if necessary by advancing and give road test. If no better, retard beyond original position and re-test.

(3) Check carburettor and filter carefully.

(4) Check valve clearances.

No spark or weak spark.—If no spark or weak spark proceed as below:

(5) Disconnect earth cable from "P" terminal (4) on Vertex and start engine. Normal spark indicates faulty earth cable or ignition switch.

(6) Remove distributor head, clean contact-breaker points with a smooth file, and adjust gap. If oily deposit present on or near contact breaker, clean thoroughly by means of a small stiff brush which has been dipped in petrol, afterwards cleaning contacts with thin, smooth file.

(7) Verify that resistance (2) is not in contact with any metal.

(8) Remove distributor head and check tightness of screw in contact-breaker base plate—beneath resistance (2)—and screw assembly (12) which secure the two primary leads. Take care to replace distributor head correctly.

(9) Verify that H.T. cables are in good condition.

Difficult Starting or Refusal to Start.—Test spark. Regular and normal spark indicates Vertex and H.T. cables in order. Further procedure as (2) and 3), above.

If *no spark* or *weak spark*, proceed as in (6), (7), (8), and (9).

High-resistance suppressors or plugs used to prevent interference with radio may cause bad starting, as they adversely affect any form of ignition by reducing spark energy at plug points. Plugs frequently oil up due to reduced running temperature, and it is essential that values of resistances are lowest possible.

Engine Overheats and Acceleration Poor.—Advance ignition.

Engine Pinks or Knocks.—Retard ignition.

Impulse Starters

In order to obtain a much better spark from a magneto for engine-starting purposes, a device known as an impulse starter is fitted between the engine drive and the magneto armature shaft. With such a device the problem of starting commercial and tractor engines is greatly simplified and in the majority of cases such engines can readily be started by hand with a minimum of effort. Once an explosive charge has been drawn into the cylinders (about two turns of the crankshaft will ensure this) the impulse starter, by causing the magneto armature to receive a sudden "flick over," will give an intense spark.

In the case of the Lucas impulse starter shown in Fig. 104 on page 100, this retards the ignition and provides a spark at a low engine cranking speed for starting purposes. The unit consists essentially of two couplings which are flexibly connected by a coil spring. One coupling is fitted on the driving shaft, while the other is secured to the magneto spindle. As the engine is slowly rotated by hand a pawl prevents the movement of the magneto rotor, whilst the driving member continues to rotate, thereby stressing the coupling spring until such time as the pawl is tripped by means of a cam in the impulse starter. When this occurs the magneto rotor is accelerated rapidly through the sparking position and a powerful spark is produced, the timing of which is retarded for ease of starting. The sequence is repeated until the engine fires and continues to run. The pawls are then held out of engagement at a comparatively low speed by centrifugal force.

The B.T.H. impulse starter is a cylindrical coupling with no protuberances. It consists of two main components, namely the *driving*

member, which is coupled to the magneto driving shaft of the engine, and the *hub assembly*, which is rigidly secured to the magneto spindle. The driving member and hub assembly are linked together by a stout spiral spring. When the crankshaft is slowly rotated the two members move together until a pawl carried by the hub on the magneto spindle is held by a stop fixed to the frame of the magneto. Any further movement of the member on the driving spindle causes the spring to be wound up, during which time the armature remains stationary. After a definite movement of this member, the pawl is released and the armature then receives a sudden impulse to rotate, causing an intense spark to be produced sufficient to start the engine. At a very low speed the pawl is thrown out of action by centrifugal force and the two members rotate as a single unit.

The recommended method of starting a cold engine fitted with an impulse starter is as follows:

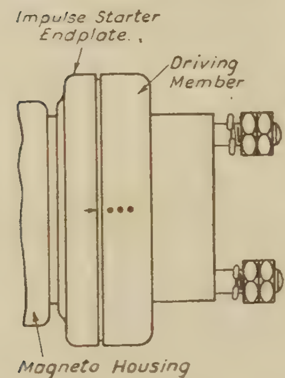


Fig. 131.—Timing the B.T.H. Impulse Starter.

(1) With the magneto switch "off" and the throttle open, turn the engine slowly two or three times, so as to fill the cylinders with mixture.

(2) With the magneto switch "on," pull up the starting handle slowly, until the pawl in the impulse starter is released and the magneto armature suddenly flicks over. As soon as this occurs, the engine should start.

Timing Impulse-starter Magnetos.—When fitting a B.T.H. magneto equipped with an impulse starter on an engine, proceed as follows:

For a Magneto Rotating Clockwise rotate the starter in an anti-clockwise direction until the three dots on the driving member coincide with the small arrow on the starter end plate, as indicated in Fig. 131. (In the case of an impulse starter fitted to the Types G, CE, or HE magnetos, it will also be necessary to see that the distributing brush is just overlapping the segment of No. 1 terminal.) At this point the contacts are just opening with the timing lever advanced, and a spark will take place in cylinder No. 1. Crank the engine to the desired firing angle and fix the magneto in this position.

For a Magneto Rotating Counter-clockwise rotate the starter in a clockwise direction until the three dots on the driving member coincide with the small arrow on the starter end plate and proceed as in the previous case.

Important.—In every case when starting, the magneto control lever should be fully advanced; the action of the impulse starter automatically provides the requisite retarded timing and obviates the danger of a back-fire.

Maintenance of Impulse Starter.—The only attention required during service under normal conditions is a few drops of machine oil occasionally inserted after removing the oil screw provided. Take care to replace the screw after oiling.

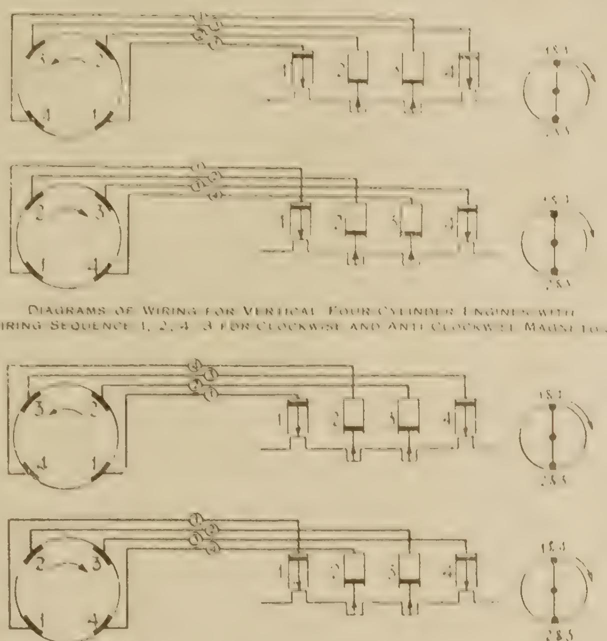
Firing Orders of Engines

It is important to know the correct firing sequence of different types of engines, when timing their magnetos or coil-ignition units or connecting up their H.T. cables. Very often an engine is dismantled and the H.T. cables are not marked before disconnecting, so that when the engine is reassembled some difficulty is experienced in ascertaining the correct plugs to which the different cables are connected.

An infallible rule in such cases is to crank the engine around so that, say, No. 1 cylinder is on compression stroke top dead centre; then remove the distributor cover and note which distributor metal segment is in contact with the rotating distributor brush. Connect the H.T. cable of this distributor to No. 1 cylinder.

This operation should be repeated with each cylinder in turn, until the complete engine has been done in this way.

Alternatively, the firing order of the cylinders can first be ascertained by the compression order method and noted down. Then the sparking-plug cables from consecutive distributor segments can be connected up to the plugs on cylinders in the firing order found. It is necessary only to couple up No. 1 plug correctly and the others as shown in Fig. 132, i.e. in consecutive order.



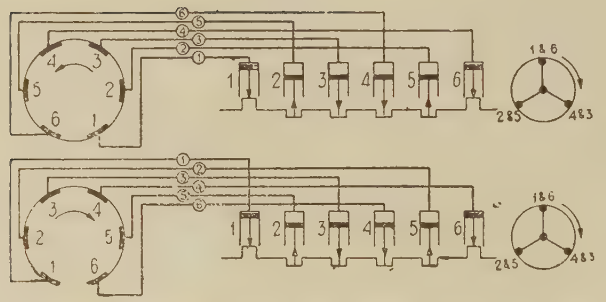
Diagrams of Wiring for Vertical Four-Cylinder Engines with Firing Sequence 1, 2, 4, 3 for Clockwise and Anti-Clockwise Magnetos.

Diagrams of Wiring for Vertical Four-Cylinder Engines with Firing Sequence 1, 3, 4, 2 for Clockwise and Anti-Clockwise Magnetos

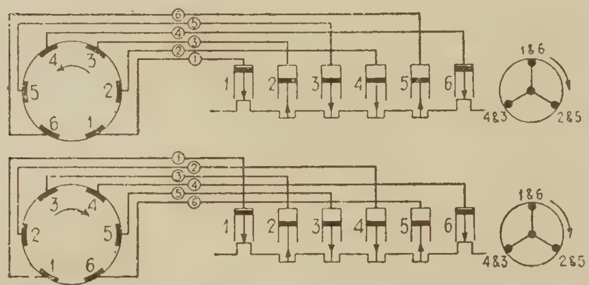
Fig. 132.—Firing Orders of Four-cylinder Engines (by courtesy of B.T.H. Co.).

To ascertain when any particular piston is on compression stroke top centre, watch the inlet and exhaust valves. The opening of the inlet valve should be followed.[1] It usually opens on top dead centre. Both valves are closed on the following compression stroke, and the top centre required is therefore one complete revolution past the point of inlet opening. This is, of course, only a makeshift method, but is sufficient for the

[1] It should be noted that the order of opening of the inlet (or exhaust) valves is also the same as the firing order.



DIAGRAMS OF WIRING FOR VERTICAL SIX-CYLINDER ENGINES WITH FIRING SEQUENCE 1, 5, 3, 6, 2, 4 FOR CLOCKWISE AND ANTI-CLOCKWISE MAGNETOS



DIAGRAMS OF WIRING FOR VERTICAL SIX-CYLINDER ENGINES WITH FIRING SEQUENCE 1, 4, 2, 6, 3, 5 FOR CLOCKWISE AND ANTI-CLOCKWISE MAGNETOS.

Fig. 133.—Illustrating Firing Orders of Six-cylinder Engines (by courtesy of B.T.H. Co.).

purpose of finding the firing order of an engine, or to identify the respective H.T. cables.

In the case of two-cylinder engines, each cylinder fires in turn, so that there is no difficulty in identifying the firing order.

Four-cylinder engines have two alternative methods of firing—some manufacturers adopt one and some adopt the other method.

If the cylinders from the front radiator end are numbered 1, 2, 3, and 4 respectively, the two firing orders in common use are as follows: Nos. 1, 3, 4, 2, and Nos. 1, 2, 4, 3. The former is the more popular system.

The firing orders of six-cylinder engines may either be: Nos. 1, 5, 3, 6, 2, 4, or Nos. 1, 4, 2, 6, 3, 5.

In the case of the eight-cylinder V-type engine, if the cylinders are numbered thus:

$$\text{Radiator end} \begin{Bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \end{Bmatrix} \text{Rear end,}$$

then the firing order will usually be as follows, although there are alternative possible orders:

1, 5, 4, 8, 6, 3, 7, 2.

The Ford V-8 Pilot engine employs this firing order.

Alternatively, if the cylinders are numbered as shown below, namely:

$$\text{Radiator end} \begin{Bmatrix} \text{Left} & 1 & 2 & 3 & 4 \\ \text{Right} & 1 & 2 & 3 & 4 \end{Bmatrix} \text{Rear end,}$$

the firing order will be:

1L, 1R, 4L, 4R, 2R, 3L, 3R, 2L.

It should here be mentioned that the firing orders of a large number of motor-cars and commercial vehicles are given in the Data Volume which accompanies this publication.

Direction of Rotation

Magnetos cannot be driven in either direction; they will only operate in the direction for which they were specially designed.

Magnetos are now made for driving either in a " clockwise " or in an " anti-clockwise " direction *as viewed from the driven end*; they are sent out marked with an arrow—usually on the oil cover—showing the direction of rotation. Sometimes the direction of rotation is marked on the collector brush holder; sometimes on the casing.

In four- and six-cylinder engines *the distributor arm* revolves in the opposite direction to the armature.

Sometimes the correct direction of rotation may be ascertained by removing the cover plate of the armature and noting the position of the armature when the contacts are just separating.

Speed of Rotation

The magneto must always be arranged to rotate at such a speed that it gives *one spark to each cylinder once every two revolutions*. Its actual armature-shaft speed will, of course, depend upon the number of distributor contacts and of contact-breaker cams.

A single-cylinder magneto for the four-stroke type of engine is driven at one-half engine speed, there being only one contact-breaker cam.

A two-stroke single-cylinder magneto must give twice the number of sparks of the preceding case. It is usual to provide *two contact-breaker cams*, and to drive the magneto at *one-half engine speed*. If a four-stroke single-cylinder magneto is employed, in the case of a two-stroke engine it must be run at engine speed.

The two-cylinder four-stroke type magneto is run at one-half engine speed, as in the second example above.

The two-stroke, two cylinder, two-cam type runs at engine speed. Four-cylinder four-stroke magnetos are driven at engine speed.

Six-cylinder four-stroke magnetos are driven at one and a half times engine speed.

Eight-cylinder engines usually employ two separate four-cylinder-type magnetos, each driven at engine speed.

If a special type of magneto having eight distributor contacts and two contact-breaker cams is employed, then it must be driven at twice engine speed.

In the case of a two-cylinder engine of the V type, a special design of magneto is employed in order to give the irregular firing intervals required; it is provided with two cams as a rule, and runs at one-half engine speed.

Timing Magneto Ignition

The operation of connecting the armature shaft of the magneto in exactly the correct position, relatively to the engine crankshaft, is known

as the " *timing of the magneto.*" Since all modern magnetos are complete self-contained units, the only item which need be altered in relation to the engine is the position of the armature shaft—the armature, contact breaker, and distributor are positively driven from this shaft, so that any change of position of the latter automatically alters the positions of the former items correctly.

Although the timing of definite types of magnetos has already been dealt with, the following more general notes will prove useful to the service engineer:

In timing any engine, it is important—in cases where new magnetos are being fitted—to see that the magneto has the correct direction of drive as explained in a preceding paragraph in this section. Taking the simplest case first, namely, the single-cylinder engine, set the piston on top of its compression stroke; move the " spark-advance " lever to its " full-retard " position and then, with the armature coupling disconnected, or loosely connected, so that the armature may be moved relatively to the engine crankshaft, turn the armature shaft *in its correct direction of rotation* until the contact-breaker arm is just beginning to mount the cam, so as just to commence to separate the contacts; this is the correct firing position and, without altering the position of the armature shaft, it should be locked to the engine drive in this position.

In some cases the manufacturers may advise some other setting of the spark-advance lever than the full-retard one—their directions should, of course, then be followed explicitly.

In the case of two-cylinder engines having equal firing intervals, the position of the contact breaker on its cam is the best indication of the firing position.

Multiple-cylinder engines, of the four, six, or eight types, can readily be timed by setting No. 1 cylinder on its compression stroke top dead centre, ascertaining which H.T. cable belongs to No. 1 cylinder—either by its marking or length—and then rotating the distributor brush or arm (in the jump-spark system) until it is making contact, or is opposite the collector segment corresponding to No. 1 cylinder—as shown by the cable, or otherwise ascertained.

The armature driving flange, or connection, should then be locked relatively to the engine driving member.

The spark-advance lever should be fully retarded when timing a modern engine in the above manner, unless the manufacturers recommend some other special setting.

The timing should always be checked, after setting, by one or other of the following methods:

(*a*) By placing another piston on its compression stroke top centre, retarding the spark-advance lever, and observing whether the H.T. distributor brush or arm is opposite the collector segment of this cylinder.

(*b*) By noting whether for No. 1 and any other cylinder the contacts of the contact breaker are just separating.

Some magnetos, notably the earlier Bosch, had a small window fitted in the distributor cover, so that the position of the armature of distributor arm could be observed without removing the cover.

Where gear drive is employed for the magneto, it is usually only possible to time by altering the position of the armature shaft one tooth at a time. The correct meshing position of the teeth is generally marked by means of lines on the gear teeth—two lines on the crests of consecutive teeth of one gear and one line on the crest of the other gear tooth to mesh with it.

It is often better to loosen the magneto flange or gear on the tapered armature shaft; in many cases this flange or gear is not keyed, and can therefore be moved relatively to the shaft for ignition-timing purposes.

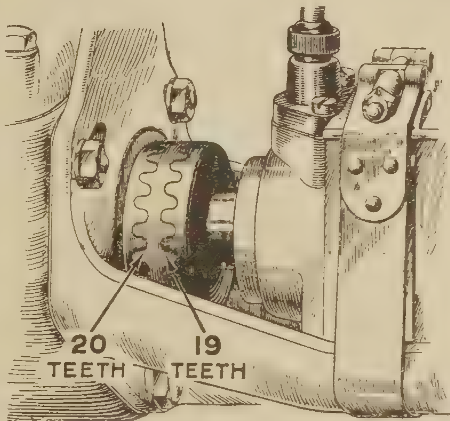


Fig. 134.—Illustrating the Vernier Method of Magneto Timing whereby it is possible to vary the Timing by about One Degree at a time.

The vernier coupling system which is used on many engines gives a sufficiently fine degree of timing variation. In the example shown in Fig. 134 there are 19 teeth on one side and 20 on the other of the vernier coupling. It is therefore possible to advance one side by $\frac{1}{19}$ of a complete revolution, and the other by $\frac{1}{20}$ of a revolution, the net result being a total advance of $\frac{1}{19} - \frac{1}{20} = \frac{1}{380}$ revolution, i.e. less than a degree. The following is the correct procedure to follow when timing an engine with the Simms type vernier coupling.

If the magneto has been removed, or it is desired for any other reason to check the timing, proceed as follows:

Rotate the engine crankshaft until the piston in the front cylinder (No. 1) is at the top dead centre of compression stroke (i.e. with both valves closed).

Take out the locking screw from the front portion of the coupling, and slide the latter along the shaft towards the water pump.

Secure the magneto to its bracket on the crankcase by means of the set-screws underneath, and then rotate the magneto spindle until, with the white-painted No. 1 appearing at the window of the magneto distributor cover and the ignition lever in the fully retarded position, the platinum points of the contact breaker will be just on the point of breaking. With the engine in the position referred to, insert the fibre middle piece of the coupling with the line marked thereon corresponding to the mark on the magneto coupling piece, slide along the front part of the coupling and insert the locking screw.

General Tests for Magnetos

For garage and general routine testing purposes it is necessary to have a variable-speed electric motor with speed indicator to drive the magneto over its usual working range of speeds. An ammeter with a range of 3 amperes on one scale and 30 amperes on the other is also useful for testing ignition low-tension circuits.

The three-point spark gap described in the previous chapter should be used to " load " and also to measure the sparking voltage.

In addition, a rotating spark gap is an important item for ignition circuit tests, since it can be employed for ascertaining the exact time or angle (crankshaft) of sparking at different (engine) speeds. It is invaluable for automatic ignition advance and retard tests. This device is identical with the synchroscope described in the previous chapter, and it is used in the same manner.

In order to simulate actual operating conditions, i.e. with the sparking plugs in their cylinders, and to take into account the effect of bridging of the gap by oil or carbon—which puts an extra load on the ignition circuit —it is usual to shunt the three-point spark gap with a resistance of 200,000 ohms. This resistance is placed across the main sparking points, and it is equivalent to reducing the distance between the points by 45 to 55 per cent. Ordinary plug H.T. current leakage due to dirty or fouled insulator may be simulated by a shunt resistance of 300,000 to 500,000 ohms.

In magneto tests, the performance in regard to spark production should be carefully checked at the hand-cranking and starting-motor speeds, and over the complete working range, namely from idling to maximum engine speeds.

The magneto speed for the ordinary car engine is one-half the engine speed in most cases, as previously mentioned.

Testing Magneto Armatures

In order to test the magneto armature for correct working it is necessary to employ a method which will involve both the primary and secondary circuits as well as the slip-ring connection and condenser.

One very convenient method is shown in Fig. 135. In this case the only additional apparatus required is a battery and a fixed condenser of about 1 mfd. capacity.

The positive pole of the battery is connected to the centre screw of the contact breaker. The negative pole is connected by means of a piece of insulated wire to a piece of copper wire B; alternatively, the end of the wire can be bared to expose the copper wire.

Another lead is connected to the slip ring, on which the H.T. current brush rests. The bared copper end of this lead should be given a turn around the slip ring and also twisted to give a good contact. The other end A of this lead should be fixed at about $\frac{1}{4}$ in. from the armature-core laminations, so as to form a spark gap.

The fixed condenser C is connected across the battery terminals as shown in Fig. 135; the condenser of the magneto is left in place for this test.

Having connected the battery, fixed condenser, and leads A and B as indicated, the negative lead B should be brought into contact with the armature-core laminations. It should then be withdrawn, and this process repeated at short intervals.

If the armature windings are in proper condition a spark should occur across the fixed gap between the lead A and the armature laminations.

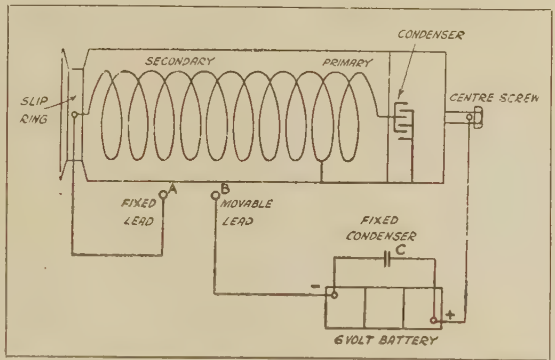


Fig. 135.—Illustrating Method of Testing Magneto Armatures.

The Slip-ring Connection

When fitting slip rings it is important to ensure that the H.T. lead from the armature is properly registered in the hole in the slip-ring boss. If incorrectly fitted, the H.T. lead may become kinked and fail to make good contact with the slip-ring insert. After fitting, the connection should be given a continuity test. Fig. 136 illustrates the method of making such a test in the case of the B.T.H. Types G, K, and M magnetos, using two brass cradles and a mains bulb with mains connections. The magneto should of course be mounted on a dry wood base for this test.

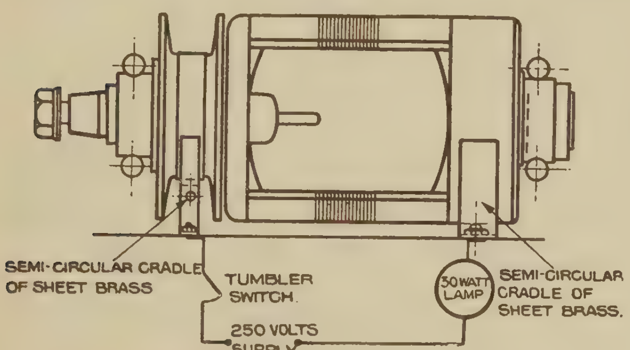


Fig. 136.—Slip-ring Connections used for Testing Purposes.

Testing the Primary Winding

In order to test the primary winding for continuity a small battery of 2 or 4 volts and a suitable lamp are required.

The lamp and battery are connected in series with the primary coil by holding one of the test leads A against the centre screw of the contact breaker, and the other end B against the armature-core laminations. If

the lamp lights it is an indication that the primary winding is intact and satisfactory.

Testing the Secondary Winding

In this case, owing to the large number of turns of fine wire employed, the resistance is very high and the ordinary L.T. battery is useless.

The wireless type of H.T. battery of 100–120 volts should be used in conjunction with a milliammeter of 0–50-milliampere range.

If these are connected in series with the secondary the milliammeter should give a definite reading of a few milliamperes. The connections for the secondary circuit are at the slip ring and at the armature core earthed end respectively. The telephone-receiver method, described previously, can also be used; when the switch is closed a distinct click in the telephone receiver indicates a continuous circuit.

Aligning the Magneto

It is important when replacing the magneto, after an overhaul or retiming operation, to ensure that it is secured to the engine base plate or other part provided for the purpose, in correct alignment with the drive

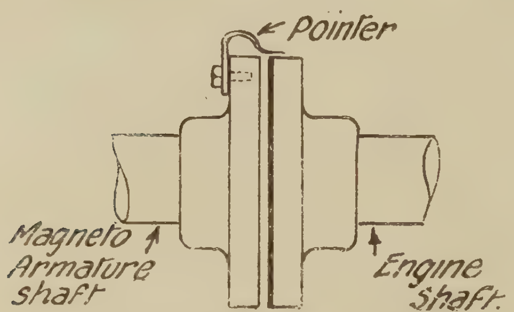


Fig. 137.—Method of Aligning the Magneto Drive.

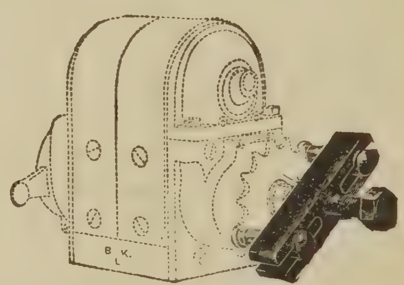


Fig. 138.—Showing a Useful Tool for Withdrawing a Magneto Chain Sprocket.

shaft. To align the magneto, firstly ascertain that the armature-shaft axis is at the same height as the driving-shaft axis, and secondly, that the axes are in line.

A good method of checking alignment which automatically checks both of the above items is to secure a pointer on one of the shaft flanges, preferably that of the armature, arranging that it is fairly close to the other flange (Fig. 137). Now turn the movable flange—in this case the armature shaft—and observe whether the distance of the pointer from the other flange varies either radially or axially. The pointer should, of course, describe a concentric circle with its plane parallel to that of the flange of the other member.

An Efficient Magneto and Coil Tester

A simple but efficient device for testing magnetos, coils, and sparking plugs is illustrated in Fig. 139. With this apparatus it is possible to test whether the magneto or coil-ignition unit is giving a good spark or whether it is the sparking plug which is at fault.

The device illustrated has a high-resistance sparking gap which is based on the correct ratio of the safety gap in the magneto and the compressed gases in the engine cylinder. It has a central sparking point placed concentrically with a sparking rim giving a gap of 5 mm. A sliding rod fitted with an insulated knob is provided. When this rod is pulled out as far as it will go it connects the magneto or coil to the high-resistance test-gap, and thus shows whether the correct voltage is being generated by the ignition apparatus. The device is used as follows: remove the sparking-plug wire and connect the test-end terminal (shown on the left) in its place. The centre terminal is connected to the sparking-plug wire, and the clip shown above is attached to any part of the engine, to give the earth. When the engine is running and the tester is coupled up as described, the sliding rod is pulled out, and if the particular circuit is working satisfactorily a distinct spark will flash across the high-resistance gap at all working speeds. To test whether the sparking gap itself is functioning, it is only necessary to hold the left-hand terminal of the tester in contact with the sparking-plug terminal, when a flash will occur at the small window in the top left-hand corner, due to the tube of neon gases fitted inside. This tester is equally suitable for checking cylinders, for misfiring or oiling up, sparking-plug point setting, dirty contacts on the contact breaker, and similar ignition trouble. The device is compact, measuring only $3\frac{1}{2}$ in. $\times$ $1\frac{1}{2}$ in. $\times$ $\frac{3}{4}$ in., and its life is indefinite.

Fig. 139.—A Magneto- and Coil-testing Device.

Care of the Magneto

The magneto, being an electrical machine, must be treated as such from the point of view of care and maintenance.

It has been so well developed that with very little attention it will give satisfactory service over long periods—but this attention is essential.

The various points of maintenance, adjustment, and attention are enumerated below:

The Contact Breaker.—After being in service for some considerable time—usually about 10,000 miles or so of road running—the contact breaker will require attention. In certain cases and with certain types, more frequent attention will be necessary.

The chief item to examine is the contacts. These not only become pitted, due to the progressive action of the slight "arcing" or sparking at the "break," but the combined effect of sparking and impact gradually increases the gap between the contacts when the latter are separated.

The correct gap should usually be ·012 to ·014 in. (or about ·4 mm.).

This clearance, when the contact breaker is in the open position, should be checked with the magneto feeler gauge provided by the makers, or obtainable at any motor accessory dealers in the form of a double-ended spanner (to fit the contact nuts and centre screw) with feeler attached.

Great care should be taken to keep the contacts *clean*, *true*, and with their *proper gap*.

The contacts should be kept free from oil or grease, as this acts as an insulator; a little will cause undue oxidation and sparking, and therefore pitting.

Badly pitted contacts should be trimmed square, using a fine-grade oil-stone. It is best to make the contacts very slightly convex. Very fine emery cloth can also be used to clean the contacts, but the use of a file is never advocated by the magneto manufacturers.

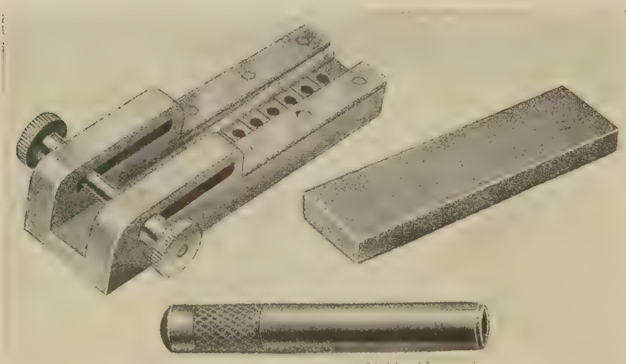


Fig. 140.—A Useful Contact Arm and Contact-truing Jig.

In the case of a "botched" or damaged contact it is best to replace with a new one; these are obtainable in platinum alloy or tungsten.

Fig. 140 illustrates a typical contact-refacing jig, which has been designed to true up both the fixed and movable-arm contacts by the method of fixing them securely in the jig and surfacing with a fast-cutting abrasive stone (Aloxite). By this means the contacts are trued up perfectly square.

The holding jig has an inclined channel and two slots, so that the breaker arm can be moved along in parallel line until the contact point projects just a trifle above the grinding-stone guides. A few rubs with the stone, shown on the right, faces the contact point down evenly and parallel with the arm axis. The stepped holes allow the contact screw to be faced off in the same way, the finished surface being smooth and exactly at right angles with the screw.

In replacing the fixed contact, take care to lock it securely in position.

Avoid fingering the contact surfaces, for a particle of dirt or a small amount of grease or oil on these will stop the magneto from working.

In the case of a double-cam-type magneto which has been in use for

some time, examine the separation of both cams, for it sometimes happens that one cam lifts more than the other; the lower-lift one should be packed with a liner of tin or copper of the requisite thickness—the cam can be detached by removing two screws for this purpose.

The only other items requiring attention are the bearing bush of the contact-elbow lever, and the cover, or base plate L.T. circuit brush.

The contact-breaker rocking lever was, previously, provided with a steel-pin fulcrum, which rocks in a fibre bush fixed to the base plate.

A *common trouble* with this arrangement was the sticking of the pin in the fibre bush due usually to the swelling of the latter under the influence of atmospheric moisture, and when a car had stood unused for a period, in a damp place, its engine would sometimes refuse to fire and the trouble could be traced to the sticking of the contact-arm pin in its fibre bush. When this occurs, *do not oil* the bush, but reamer it out with a suitable round reamer—not with a file end or nail. Care must be observed in this operation, otherwise a tapered or oval hole will be made, and the contact lever will rock in this hole, causing bad fitting of the contacts.

It may be added that with the synthetic resin bushes now fitted this trouble is not experienced.

The Collector Ring and Distributor.—The armature shaft H.T. pick-up usually consists, as we have previously explained, of one or two brass segments connected to the secondary coil end embedded in a V-pulley-shaped insulator. A carbon brush E, or carbon brushes, collect the H.T. current from this slip ring P and convey it to the distributor-arm brush (Fig. 102 on page 97).

When overhauling a magneto, the slip ring and also the distributor disc—if of the rubbing contact type—should be examined for scoring or grooving due to the action of dirt. If any appreciable scoring is found it should be removed by turning a small amount of the surface off in a lathe. Usually, however, a pad of fine emery paper can be used to clean the contact segments.

If the surfaces are merely dirty—a black greasy deposit, due to carbon wear, obscuring the metal—they can be cleaned with a piece of soft cloth dipped in petrol, finishing off with a dry piece of the same cloth.

The carbon brushes should be examined for excessive wear and, if necessary, replaced. Any hard glazing of the rubbing end should be removed by filing.

Do not tamper with the springs of the brushes, nor attempt to make a new spring to replace a lost one—except in emergency. It is not an easy matter to ascertain the correct compression and length of a spring; too much will cause excessive wear of the brush, and too little misfiring.

It is advisable to clean the slip ring and distributor at least once every 3,000 to 4,000 miles.

Some makers recommend a light smear of oil on the distributor plate or ring after it has been cleaned; this is stated to prevent excessive wear.

Weak Magnets

Remagnetising.—The construction of magneto magnets has undergone radical alteration of recent years, and tungsten-steel has been almost entirely superseded by cobalt or cobalt-chrome steel alloys. These possess a remarkably high coercive force and ability to resist demagnetisation, provided they have been subjected to correct heat-treatment in the first place. Weak magnets are not, therefore, so frequent as they were originally, but when remagnetising does become necessary it requires a somewhat different treatment and a more intensive application of remagnetising force than when tungsten steel was used. The exciting coils of a serviceable remagnetiser must provide an excitation of at least 60,000 ampere-turns to be effective.

Various designs of magnetisers for this purpose are on the market. Figs. 141 to 144 are typical examples of these.

The practice is to treat the magneto in its entirety, not separating the magnets from the frame as formerly. The poles of the magneto are placed between the adjustable pole-pieces of a remagnetiser, such as Fig. 143, brought up into close contact, and current from a 24-volt battery flashed through the windings by means of a spring press-switch seen at the base. The lamp socket is for a "buffer" lamp, which is a shunt circuit to the windings enabling the inductive discharge to find a path for its energies on collapse of the main flux without stressing the insulation too much. It is not advisable to use these remagnetisers on high-voltage circuits, the inductive spark on breaking circuit being difficult to deal with.

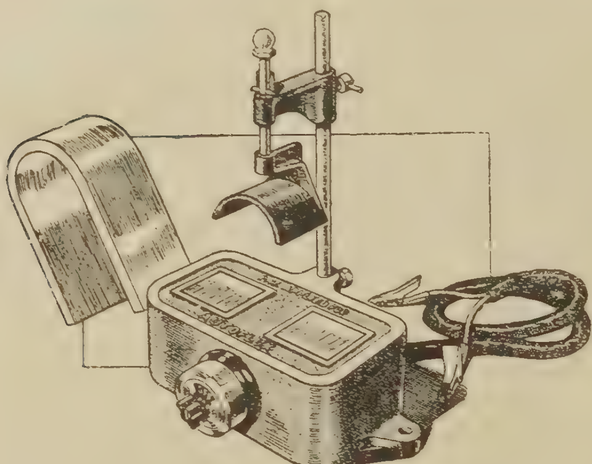


Fig. 141.—The Autoflux Magnetiser.

To use the remagnetiser shown in Fig. 144 the magneto is clamped between the two poles, making sure that the polarity of the magneto's magnets agrees with that of the apparatus. It is also advisable to clean any dirt, oil, or grease off the magnet surfaces where they make contact with the remagnetiser poles. The switch should be pressed down three or four times for a period of a few seconds each; a lamp, in series, will illuminate each time if the magnetising coils are in good order. The magnets will be fully magnetised by this procedure.

It should here be emphasised that direct current only must be used for the remagnetiser.

The Runbaken Magnetiser.—Fig. 142 shows the Runbaken magnetiser, which is suitable for remagnetising the magnets of magnetos, electrical machines, and instruments.

It consists of a pair of solenoid-wound pole pieces on the top of which is placed the magnet to be remagnetised; the polarities of the solenoid and the latter should, of course, be appropriate.

The apparatus in question is provided with a signal lamp to show when the current has been switched on; a single-throw switch is fitted for this purpose. The magnetiser is suitable for all direct-current supply voltages ranging from 6 to 220 volts, and it has a low current consumption.

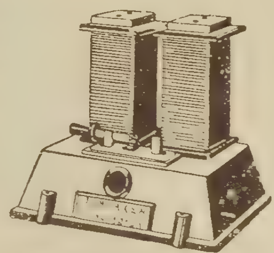


Fig. 142.—The Runbaken Magnetiser.

Care of the Magneto

After a magneto has been dismantled it is advisable to protect the permanent magnets against loss of strength by bridging the poles with a piece of soft iron or mild steel. This should be kept in position all the time the magnets are stored. Fig. 145 shows one method of shunting the poles by means of soft-iron keepers held in place by screws A and B. Here the U-clip forms the return path for the magnetic field. Normally, in the case of horseshoe magnets, the iron keeper will be held firmly in position on the magnet poles by magnetic attraction alone.

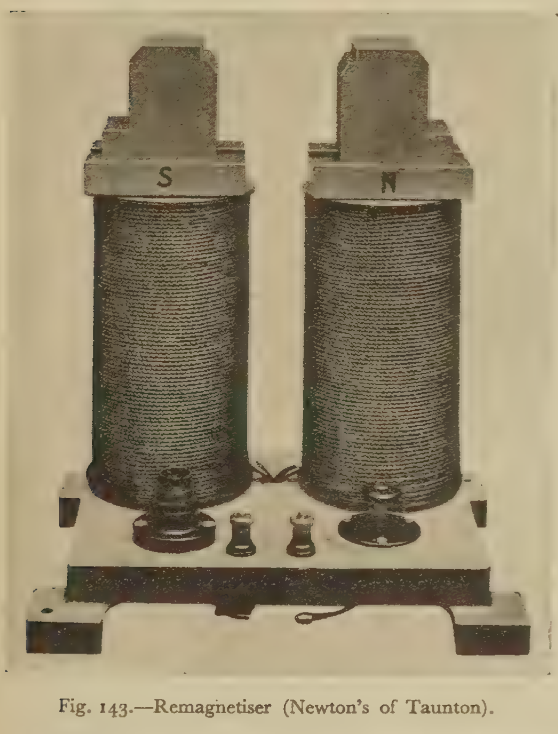


Fig. 143.—Remagnetiser (Newton's of Taunton).

Making Cable Joints

It is important to ensure that the H.T. cables are securely and electrically connected to the cable ends and also to the magneto H.T. distributor. Each type of magneto has its own particular method of attachment of H.T. cable, so that a few notes on the subject may prove useful.

The majority of distributor connections are of the concealed type, as shown in Fig. 146. To connect the cables, first unscrew the fixing screws

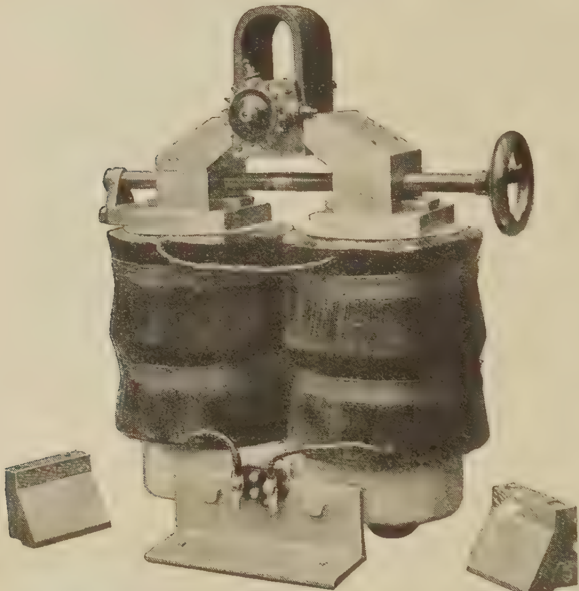


Fig. 144.—Another Type of Commercial Remagnetiser that does not require the dismantling of the Magneto (G.E.C.).

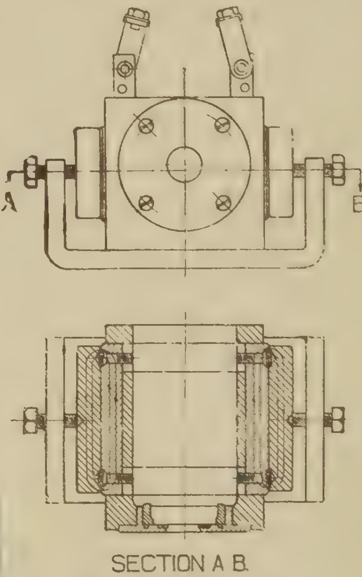


Fig. 145.—Showing Soft-iron Keepers for Shunting Magneto Magnets.

until the points are clear of the holes, cut the wire and insulation of the cables level and push them down to the bottom of the holes. The fixing screws should then be tightened up as far as possible, when the sharp point of the screws will pierce both rubber and cable (as shown in Fig. 146), forming a perfect, permanent connection. As a precautionary measure, a test may be made for continuity of circuit between the fixing screw and the other end of the cable, i.e. that which is to be connected to the sparking plug. This will ensure that the fixing screw has actually penetrated the stranded cable core, and is not merely pinching the rubber.

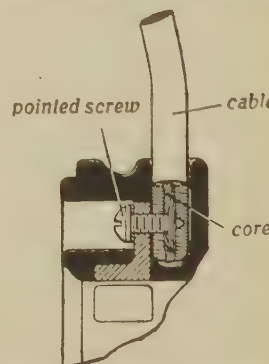


Fig. 146.—The C.A.V. H.T. Cable Attachment.

Figs. 147 and 148 illustrate the Lucas H.T. cable connections.

The method of securing the distributor H.T. cables to the distributor is illustrated in Fig. 148; 7-mm. rubber-covered ignition cable (shown at A) is used. The cable should not be bared but cut flush to the proper length. Then remove the distributor and unscrew the pointed screw B. Push the H.T. cable hard and secure it by tightening the screw B, which will pierce the insulation and make contact with the copper-wire conductors inside.

The method of securing the H.T. cable to the carbon-brush holder which carries the cable to the magneto is shown in Fig. 147; 7-mm. cable is employed, except in the Lucas KR magnetos, where 9-mm. cable is used.

To secure the cable, first remove carbon brush A, then unscrew and remove the pointed screw, push the cable C hard home, as shown in illustration. Replace screw, and by screwing same back as far as it will go, the points will pierce the insulation and make perfect contact. Replace carbon brush and refit pick-up to magneto.

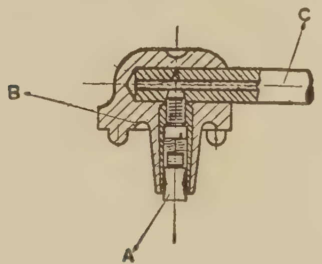


Fig. 147.—The Lucas H.T. Cable Connector. A, Carbon Brush. B, Insulated Connector. C, H.T. Cable.

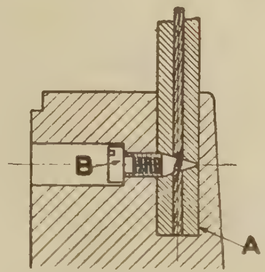


Fig. 148.—H.T. Cable Connection.

The C.A.V. magneto H.T. cable fixing uses a pointed screw.

Fig. 149 illustrates a method of making eyelets for H.T. cables. The core of the cable is laid bare for a distance of 22 mm. by scraping, diagram (1). A little tallow is applied to the end of a small brass tube, diagram (2), the latter being slid over the cable core and pushed into the insulation as shown in diagram (3), Fig. 149, until the projecting end measures 22 mm. The tube is then bent into a ring, or eye, as shown in diagram (4), Fig. 149, using a pair of round-nosed pliers for the purpose.

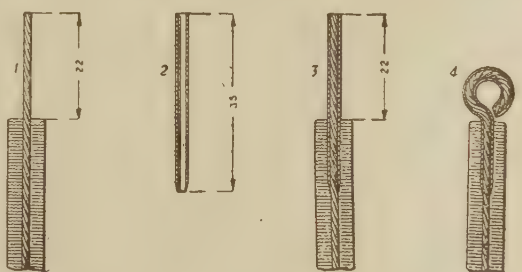


Fig. 149.—Method of making Cable Eyelets.

The Care of Typical Magnetos

As the design of magnetos is somewhat different in the case of two typical magnetos in use on modern cars, some notes will here be given on the care and maintenance of these individual magnetos.

The Simms Magneto.—The various points of maintenance attention of the Simms magneto are illustrated in Fig. 150. The information given in the following instructions is based upon motor-bus operation, namely about fifteen hours a day, for the four-cylinder type of magneto.

Referring to the numbered items in Fig. 150, the following are the special points of attention:

(1) Oil well for driving-end ball bearing. Fill oil well WEEKLY.

(2) The safety spark gap is set at 9 mm.

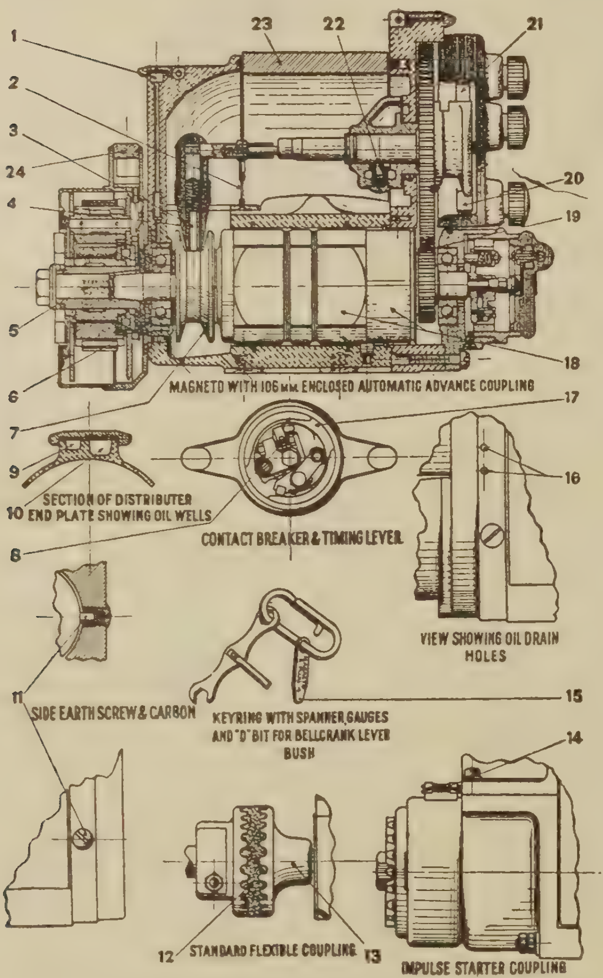


Fig. 150.—Illustrating Magneto Maintenance Items. (The Magneto shown is the Simms.)

(3) See that carbons work freely in holders.

(4) Clean tapered end of collector-carbon holder MONTHLY.

(5) When removing magneto coupling, do not hit end of armature spindle with a hammer.

(6) The outer race of the ball-bearing is insulated from the magneto body by presspahn rings and washers to prevent primary current passing across bearing and destroying it.

(7) Clean bevelled sides of slipring MONTHLY.

(8) Gap between contacts when breaking should be ·015 in. (·4 mm.) (to gauge).

(9) Oil well for contact-end ball bearing and fibre heel of contact breaker. Fill oil well WEEKLY.

(10) Oil well for plain bearing of half-speed wheel spindle. Fill oil well WEEKLY.

(11) Remove any oil from earth brushes MONTHLY.

(12) Note that any excessive thrust caused by mounting the magneto driving-coupling up too tightly has a detrimental effect on the contact-end ball bearing. If the coupling is a Simms special vernier-type, allow the rubber to float slightly.

(13) Do not knock coupling off with a hammer.

(14) Oil impulse starter once per week. Use thin oil.

(15) Check up plug gaps with gauge FORTNIGHTLY. Gaps should not exceed ·020 in. (·5 mm.).

(16) Keep oil overflow holes in distributor end plate clear.

(17) Clean out timing lever MONTHLY.

(18) Do not wash the armature and condenser assembly in petrol or benzol.

(19) When removing spindle nut, do not place a screw-driver between the magneto gears to hold the armature stationary.

(20) Clean distributor track MONTHLY. Do not use emery cloth.

(21) See that carbons work freely in holder.

(22) Replace oil wick every time magneto is dissembled.

(23) Use brass and not steel traps for fixing magneto.

(24) Oil automatic advance WEEKLY, with the heaviest possible engine oil. Change the wiring YEARLY. Do not swab down the magneto with petrol or paraffin. If these or similar liquids are absorbed by the felt strips or find any access to the inside of the magneto, the vapour given off is extremely detrimental to the platinum-iridium contacts. If the magneto is located beneath a carburettor or near the crankcase breather, place a tray or shield so that no oily vapour enters the timing-lever housing. Always lubricate magnetos, automatic advance couplings, and impulse couplings at the end of the day's run when the engine and the magneto are warm. The oil will flow easily and the excess oil will then drain away.

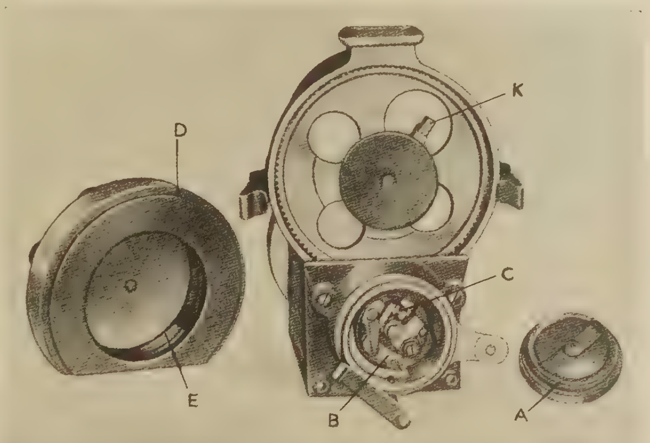


Fig. 151.—Illustrating the Timing of the Simms Magneto used on Leyland Vehicles.

Timing the Simms Magneto.—The Simms magneto, as we have previously explained, is driven by a flexible vernier coupling from a shaft in the timing case.

In order to explain the method of timing the Simms magneto we shall refer to the case of the Leyland commercial-vehicle engine, fitted with the six-cylinder type of magneto, Model S.R. 6 L., with 40° range of ignition control.

Referring to Fig. 151, the contact points C should be just breaking when piston is on T.D.C. with the control arm of the contact breaker in the fully retarded position. This point is marked on the flywheel and flywheel housing. The flywheel is marked to give top dead centre of pistons 1 and 6, 2 and 5, 3 and 4.

In Fig. 151, A is the contact-breaker casing cover and B the moving or pivoted arm of the contact-breaker unit.

To retime when replacing magneto, crank engine until No. 1 piston is on T.D.C. on compression stroke—i.e. both valves closed; trace cable from No. 1 plug to the segment on the distributor cover D (Fig. 151), and turn magneto spindle in direction shown by arrow on the oil-box lid until the points are just breaking when the distributor brush K is on the segment E corresponding to No. 1 cylinder; the control arm on the magneto contact breaker to be in the position corresponding to the full-retard position of the control lever.

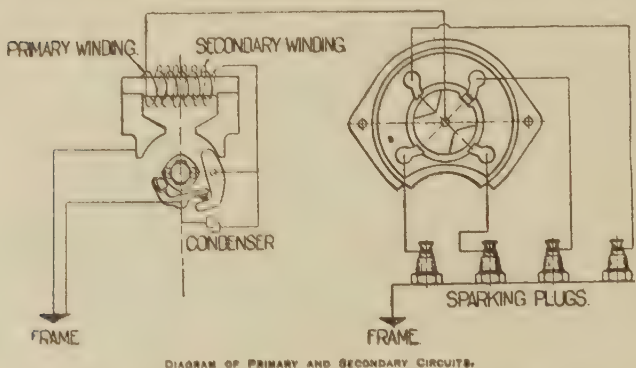


Fig. 152.—The B.T.H. (Four-cylinder) Magneto Wiring Diagram.

To facilitate tracing cables, these are of six different colours.

Set the vernier coupling in such a position that the magneto will slide in without altering the position of the spindle.

Do not press the coupling up too tightly, as this leads to rapid failure of the coupling and probable failure of the magneto end-bearing.

If trouble is experienced by the teeth of the coupling shearing, test for alignment.

With the pistons in clean condition and using ordinary commercial petrol, the engine should be " pinking " slightly when on full throttle at 15–20 m.p.h. in top gear with the ignition fully advanced. If the engine does not " pink " on this setting, advance the magneto slightly until the desired condition is obtained, care being exercised that the magneto is not advanced to such a position that it will cause a " kick back " when starting on full retard.

The B.T.H. Rotating-armature Magneto.—This type of fixed-magnet, rotating-armature magneto, known as the G or GL one, operates upon the same principle as those previously described, so that it is unnecessary here to consider its operation.

In regard to *the maintenance* of this magneto, the following notes cover the important points requiring attention. An opportune time for attending to the magneto is when decarbonising the engine, which is usually done every 3,000 to 5,000 miles.

Lubrication.—The rotating armature of the magneto is fitted with two ball bearings which are packed with lubricant before the magnetos leave the works.

Do not lubricate the magneto too frequently. The only part requiring lubrication is the distributor gear-wheel bearing, and *eight drops of light oil* poured into the oil well at the distributor end of the magneto every 2,000 *miles* are sufficient.

In the case of magnetos for special drives and fitted with greasers, the following lubricating instruction will apply:

One turn of the greaser every 2,000 miles is sufficient to keep the distributor gear-wheel bearing lubricated. Replenish grease cup with Price's "Belmoline" A, or similar grade of grease.

The platinum points of the contact breaker must be kept absolutely free from oil.

This is of the utmost importance, because the oil on the contacts becomes oxidised and prevents good electrical contact between the platinum points when closed. The current from the magneto may be reduced considerably, due to this cause.

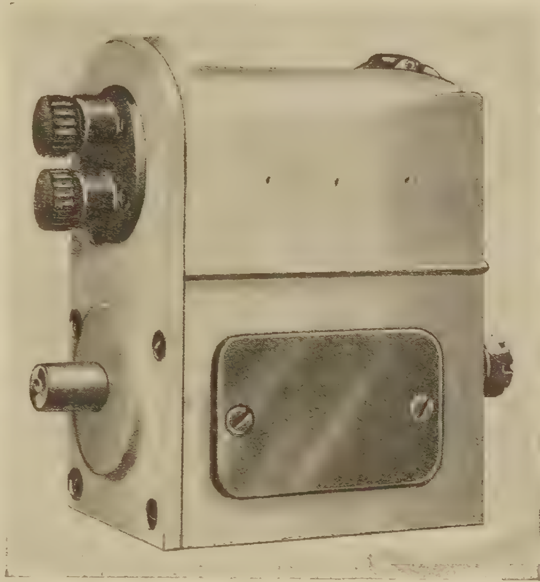


Fig. 153.—The B.T.H. Polar Inductor Magneto.

Distributor and Brush Holder.—Remove the distributor and clean the inside of it with a cloth soaked in petrol. Any dust or foreign matter that may accumulate inside the distributor is liable to cause leakage, the symptoms of which are misfiring or poor starting.

In a similar manner, wipe the surface of the brush holder, particularly between the safety-gap electrodes.

Slip Ring and Collector-brush Holder.—Remove the aluminium dust cover at the driving end of the magneto and take out the collector-brush holder which is secured to the top of the main housing by two screws, and with a cloth soaked in petrol wipe off any dust from the cone of the collector-brush holder. *Do not remove the carbon brush from the collector moulding.*

Clean the flanges of the slip ring in a similar manner. This can be done by *lightly* pressing one corner of the cloth between the slip-ring flanges and slowly turning the engine crankshaft.

Contact Breaker.—The contact breaker is readily accessible by removing the cover, and can be withdrawn from the magneto after unscrewing the centre fixing screw.

Examine the contacts and if these are dirty the surface of each contact should be cleaned with a piece of very fine emery cloth or paper, care being taken to remove any emery dust which may accumulate.

Examine the bell-crank lever-bearing bush and, if dry, smear with a little light oil. After refitting the lever on the bush it is important that any excess of oil should be wiped off.

Refit the contact breaker, *taking care to locate the key on the contact-breaker base in the keyway of the armature spindle.* With the feeler gauge on the spanner supplied with the magneto, check the contact gaps when the heel is on the high part of the cam. This gap should be ·012 in. and, if necessary, should be carefully adjusted to this dimension with the aid of the feeler gauge and spanner. *Do not adjust the contact gap unnecessarily.*

Timing the B.T.H. Magneto.—It is important to note that the distributor-brush holder runs in the opposite direction to the armature. A right-hand magneto armature runs clockwise and a left-hand magneto armature anti-clockwise when viewed from the driving end. Consequently, when viewed from the distributor end, the distributor brush rotates clockwise in a right-hand machine, and anti-clockwise in a left-hand machine.

(*a*) Place the magneto in position on the bed plate. The fixing screws are to be left loose and the coupling, also, is to be left loose on the spindle. If the gearwheel or coupling is keyed to the armature shaft instead of being tightened up on the taper, it should be secured before the magneto is fixed. In this case the portion of the drive connected to the engine should be left loose.

(*b*) Revolve the engine by hand in the usual direction of rotation, until the piston of cylinder No. 1 is near the end of its compression stroke, and in the position of maximum advance at which good running is obtained. This position is often marked on the flywheel, but if this has not been done, the position should be ascertained from the engine manufacturers.

It is most important that no stress be thrown on the driving spindle of the magneto, due to incorrect alignment of the coupling. The alignment can easily be checked for, with the magneto only loosely fitted, when the engine is revolved by hand there should be no movement whatever of the frame of the magneto. When the alignment has been checked, the fixing screws should be tightened, and if a strap is provided this should be secured.

(*c*) When the engine is in position for firing No. 1 cylinder, turn the magneto armature in the direction indicated by the arrow until the distributing brush is opposite No. 1 segment on the distributor and the contacts are just on the point of opening. The engine drive should then be coupled up.

(*d*) Connect the distributor terminal (which is connected to the segment adjacent to the distributor brush) to the sparking plug at No. 1 cylinder. Connect the remaining terminals, in the order in which the rotating brush passes them, to the cylinders in the order of their firing sequence.

By causing the breaking of the primary circuit to take place earlier or later, the timing of the ignition is varied. To effect this, the timing lever carrying the two-point cam can be partially rotated and thus produce an earlier or later opening of the contact-breaker contacts, causing a vari-

ation in the time at which ignition occurs. A variation of 25° with regard to the armature spindle is provided for, which corresponds to 33° on the crankshaft of a three-cylinder engine, 25° on a four-cylinder engine, and 17° in the case of a six-cylinder engine.

Dual-ignition Apparatus

Although the coil-ignition system is quite reliable, it is open to one important disadvantage, namely that of battery failure, for should there be no current from the battery the ignition circuit will be "dead." The magneto is, however, thoroughly reliable, and its operation is independent of the battery. On the other hand, coil ignition has certain advantages in the matter of easy-starting and slow-running qualities over the magneto.

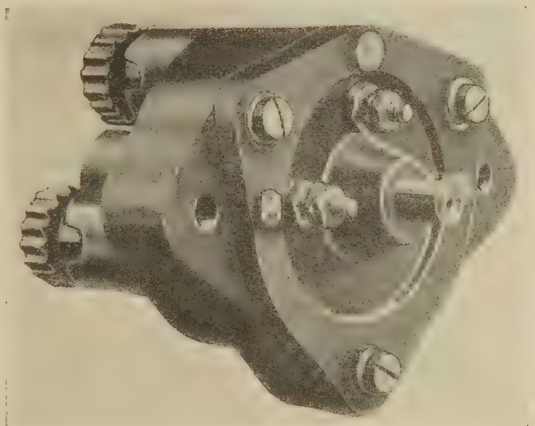


Fig. 154.—The B.T.H. Dual-ignition High- and Low-tension Change-over Switch.

The advantages of both systems are combined in the so-called dual-ignition apparatus which is to be found on certain of the more expensive makes of car still in service, and on some older commercial vehicles.

The B.T.H. system employs a polar inductor magneto, but with the contact breaker and distributor separately driven by means of a change-over switch (Fig. 155) the ignition can be provided either by the magneto or coil and battery; the same contact breaker and distributor are employed for both systems.

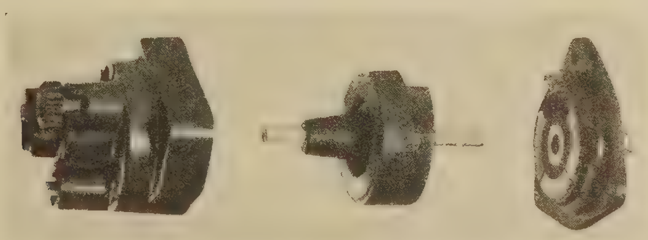


Fig. 155.—The Change-over Switch, Dismantled.

The change-over switch is fitted on the dashboard. It has three positions marked "C," "Off." and "M" (Fig. 156), denoting respectively

that the coil ignition is switched on, the ignitions are both "off," and the magneto ignition is switched on.

The connections for the magneto, the switch, and coil are shown in Fig. 157. It is important when making the wiring connections to see that the leads are taken to their respective correct terminals, otherwise there is a possibility of the battery being placed across the magneto, and in consequence the magneto unit may become demagnetised or damaged.

Maintenance of B.T.H. Dual-ignition System

The following are some brief notes on the lubrication and maintenance of this system.

Lubrication of Main Bearings.—These are packed with grease before leaving the works and should not require attention for many thousands of miles, but a few drops of good-quality thin oil should be introduced to the driving-end bearing every 2,000 to 3,000 miles, through the oil well situated in the cover.

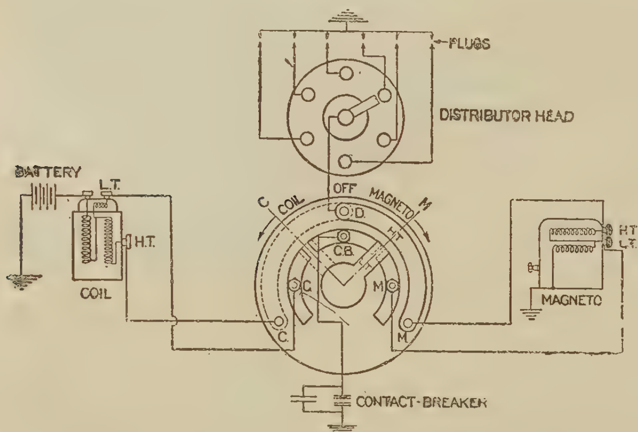


Fig. 156.—The B.T.H. Dual-ignition System for Six-cylinder Engine.

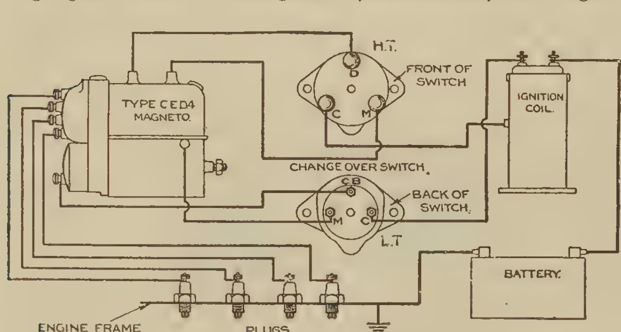


Fig. 157.– B.T.H. Dual-ignition System, Four-cylinder Engine.

Contact Breaker.—This magneto unit is intended to operate with a ·012-in. gap when the contacts are fully opened and may be checked periodically with a feeler gauge. Do not unnecessarily adjust the contact-gap points. It is important to keep the contacts clean, and especially free from oil, which oxidises and thus impairs the efficiency of operation.

Distributor and Distributor Head.—These may be cleaned every 3,000 to 5,000 miles with a cloth soaked in petrol followed by rubbing with a clean dry cloth.

Change-over Switch.—As very little sparking takes place in this component, no special precautions need be taken, but during an overhaul it may be cleaned in a similar manner to the distributor, and the brass segments polished up with fine emery cloth.

The Vertical Magneto-Coil System

A development of the B.T.H. dual-ignition system is that in which a camshaft (half-engine speed) magneto of the vertical pattern replaces the usual distributor head of the coil-ignition system. It belongs to the rotating-magnet pattern with automatic timing mechanism operating in an oil bath, and gives a good spark at engine starting speeds. The complete system comprises a type JD vertical magneto, ignition coil, and

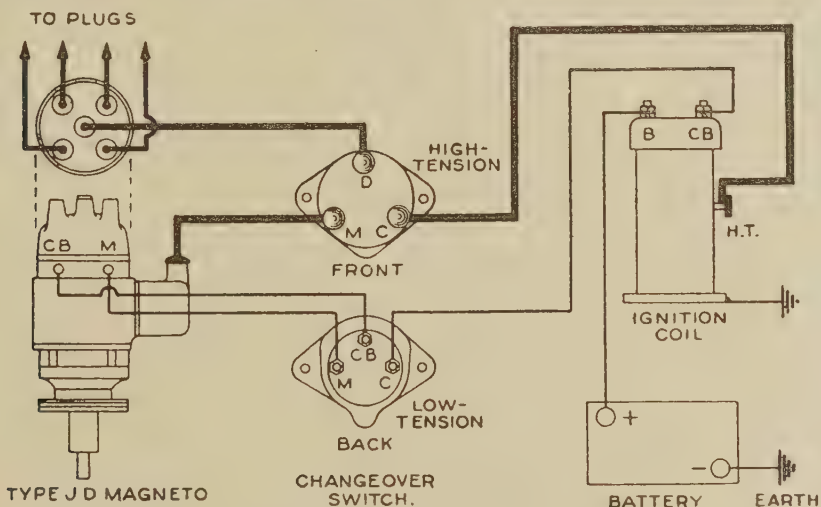


Fig. 158.—The B.T.H. Dual-Ignition System, using Vertical Magneto.

a combined H.T. and L.T. change-over switch operated by the driver. Thus, the magneto may be switched out of action whilst running on the coil. As before, the contact breaker of the magneto is used for both systems of ignition.

Fig. 158 illustrates the wiring connection diagram for the B.T.H. vertical magneto-coil dual-ignition system. The thicker lines indicate the H.T. cables and the finer lines the L.T. ones.

Detection of Faults (*Dual-ignition System*).—If trouble occurs, it is advisable to make sure that the ignition systems are actually at fault before making any adjustments.

(1) First ascertain whether the ignition is faulty on both coil and magneto by changing over from one system to the other. If the trouble exists with both systems, an examination should be made of those parts common to the two systems, namely sparking plugs, distributor, and contact breaker.

(2) Should the fault be revealed as being on the magneto system only:

(*a*) Check the H.T. cables from the magneto to the change-over switch. This may be done by disconnecting the two H.T. cables from the magneto (one on the centre of the distributor, the other on the winding cover) and bridging these terminals with a short length of H.T. cable. Satisfactory ignition will indicate that the insulation of the H.T. cables in question is faulty.

(*b*) If the fault persists, next disconnect the L.T. cables from the magneto (terminals CB and M, Fig. 158) and bridge these terminals with a short length of insulated wire. Should this remove the trouble, then the L.T. cables in question should be examined for a short-circuit to earth.

(3) Should the fault be revealed as being on the coil system only:

(*a*) Remove the H.T. cable from the centre distributor terminal and connect this terminal direct to the H.T. terminal of the ignition coil. Satisfactory ignition will indicate a defect in the H.T. cables to terminals D and C, Fig. 158, of the change-over switch.

(*b*) If necessary, next examine the L.T. connections to the switch ignition coil and "CB" terminal on the magneto. A loose connection at any of these points will cause faulty ignition in the coil system.

(*c*) Next, disconnect the L.T. cables from the CB terminals on the magneto and ignition coil and connect these terminals direct, by means of a separate piece of insulated wire. Improved ignition will indicate an "earth" on one or other of the L.T. cables.

(*d*) A faulty battery or battery connections should be looked for in case of ignition trouble in the coil system only.

No special maintenance is needed for the coil and change-over switch other than a periodical examination to see that the terminals are both tight and clean.

Ignition Troubles and their Cures

A good account having been given in the preceding pages of this and the previous chapter of the various components in both battery and magneto ignition, their maintenance and adjustment, it remains to add a few notes on the subject of tracing ignition troubles.

It is important to be able to distinguish *ignition* from *carburation troubles*, for a good deal of time may be spent in following a false symptom if one is unfamiliar with the subject.

The commonest trouble experienced in the case of petrol engines is that of misfiring—that is, irregular running due to one or other of the cylinders failing to ignite their mixture.

The Causes of Misfiring

Misfiring may be due either to bad carburation or to faulty ignition, and it is necessary to find out which is the contributory cause.

There is no hard-and-fast rule as to which system to examine first, although a few preliminary tests will quickly indicate which is at fault.

If the ignition is tested first by the method of short-circuiting each sparking plug in turn, if there is *a faulty plug* it will be revealed by this test. On " shorting " each plug the speed of the engine will decrease noticeably in the case of the ignition to that cylinder being satisfactory. If, however, one finds on " shorting " any particular plug that no difference in the engine speed occurs, this shows that either the sparking plug or its cable is at fault.

The ordinary screw-driver method is quite satisfactory for this test, although a more convenient method is to use one of the neon glow discharge tubes sold for the purpose under the trade names of Mitchell or Runbaken.

Another method of ascertaining which cylinder is misfiring is to start the engine from the cold, stopping the engine after a few minutes and then feeling each plug in turn; *the one which has been misfiring will be appreciably cooler than the others.*

To test whether the misfiring is due to the cable or the plug, take out the latter and lay on the cylinder top, with the plug terminal clear of any cylinder metal. Connect up its cable, and whilst the engine is being cranked watch whether the plug is sparking satisfactorily.

If the plug is suspected, replace with a new one, and test again, when the fault will be disclosed.

Misfiring may also be due to *bad contacts* on the contact breaker. The contacts should be examined for pitting and for excessive opening, in the manner previously described.

The carbon brushes, slip ring, and distributor segments should also be examined if the above items have been checked but without curing the misfiring trouble in the case of wipe-contact magneto.

If the misfiring still persists after the above items have been examined, the fault may then be due to one of the following: (1) *Faulty primary circuit.* (2) *Faulty secondary circuit.* (3) *Faulty condenser.*

The *primary circuit can be tested* by inserting a flash battery and pea-lamp or low-reading voltmeter in series with the winding, and noting whether the lamp fails to light or the voltmeter to register; in this case it is evident that there is a break in the circuit.

The secondary circuit may be tested in the manner described earlier in this chapter.

Very weak magnets, due to long continuous use of the magneto, are another possible cause of feeble sparking.

If the safety spark-gap points are set too close, misfiring may occur due to the H.T. current finding an easier path than across the sparking-plug points.

Sometimes the engine will run regularly for a time and will then commence misfiring; this may be due to oil or dirt on the sparking-plug points. Another cause when starting is bridging of the plug points with

fuel; this frequently occurs with two-stroke engines, which use the "petroil" lubrication system.

Total Ignition Failure

If the ignition fails entirely, as shown by the absence of sparks at the plugs when the engine is cranked, the cause of failure may be one of the following:

(1) *Contact-breaker rocker-arm brush.* This, if of fibre, sometimes swells under the influence of moisture and, as we have previously explained, binds the contact lever, so that it remains in the "open" position. This was the most fruitful source of ignition failure; the remedy has already been discussed in the "Contact Breaker" paragraphs.

(2) *Earthing cable* from L.T. terminal of magneto to the starting switch having accidentally become "earthed" to the frame of car—usually through detachment.

(3) *Broken collector* or distributor brush.

(4) *H.T. cable* (in the case of battery ignition) disconnected from coil terminal.

(5) *Defective H.T. coil* (or secondary windings).

(6) *Defective condenser.* The tests for this fault are described under the heading "Condenser."

(7) *Wrong timing of ignition.* If the spark does not occur at the correct point on or near the end of the compression stroke—within the limits of the spark advance—the engine will not run. Sometimes this is manifest by occasional bangs in the silencer as the engine is cranked around. Cases occasionally occur of magneto drive couplings working loose and slipping on their shafts, thus causing wrong ignition timing. There have been cases on record in which the magneto was erroneously timed to fire, not on the compression but *on the exhaust stroke.*

(8) *Water in the magneto* will usually cause a total cessation of the ignition, due to short-circuiting. A damp magneto should be dried out slowly in a warm—but not hot—place. Care must be taken not to use sufficient heat to damage the insulation of the wires.

CHAPTER 5

THE SPARKING PLUG

THE general performance and reliability of any engine depends to a certain extent upon the suitability of its sparking plugs.

Apart from the various points of difference in the dimensions and general design of engines it is necessary to consider the possibility of the plugs *oiling up*, their *self-cleaning* and *heat-conduction* qualities.

Each type of plug has its own self-cleaning temperature and is therefore suitable on its own particular type of engine.

With cool-running engines where the plugs are liable to soot or oil up the most suitable plugs are those with an insulator similar to that shown in Fig. 159; here, the base of the insulator is separated both from the central electrode and also from the inner wall of the plug body.

This type of plug is not suitable for high-speed engines, as the base of the insulator would get too hot and thus cause pre-ignition. Fig. 160

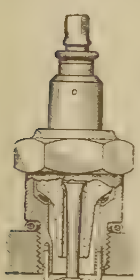


Fig. 159.—Sparking Plug suitable for Slow-running Engines.

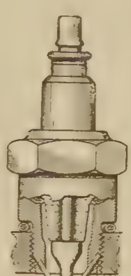


Fig. 160.—Sparking Plug unsuitable for High-speed Engines.

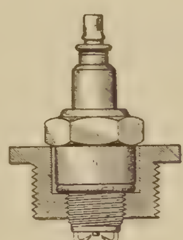


Fig. 161.—Unsuitable Position of Plug Points.

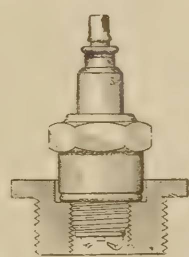


Fig. 162.—Position of Plug Points for High-speed Engines.

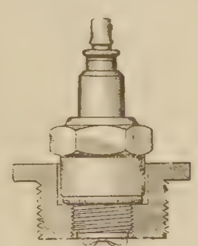


Fig. 163.—Wrong Position of Points for High-speed Engines.

shows a suitable plug design for high-speed, high-compression engines. In this case the central electrode is short and thick so as to more readily conduct the surplus heat away.

In regard to the selection of plugs, it is the *insulator* that determines whether a plug will be hot, cold, or of normal temperature in service. Thus if the insulator portion between the central point and its seating in

the plug metal shell is short the heat from the point will travel through the insulator more rapidly than for longer insulators. The plug will therefore run " cold " and will be suitable for hot-running engines. On the other hand, if the portion of the insulator from the electrode end to the insulator seating or gas-tight joint in the metal shell is relatively long, the heat will not be conducted away so quickly, and the plug will therefore run " hot." Such a plug is unsuitable for modern high-compression engines, although it would be applicable to slower-speed low-compression ones. It should here be pointed out that the plug should not run too cold or the carbon deposit that forms on the insulator will not be burned off.

The plug points should not project beyond the combustion-chamber wall in modern engines. For this reason the arrangement of the plugs shown in Figs. 161 and 163 is unsatisfactory, since it would tend to provide " hot spots " in the thread portion, and the electrode would become overheated.

In the case of plugs used in " oily " engines the single-point type is preferable to the multi-point one, as the risk of oiling up is thereby reduced to a minimum.

When selecting a new sparking plug for a given engine it is important to ensure that the plug points are in the correct position relatively to the wall of the combustion chamber. If the points project beyond the latter, pre-ignition or oiling up is likely to result.

In the case of high-speed car engines it is usual to arrange for the plug points to lie just below the surface of the combustion chamber, in a kind of shallow pocket, as shown in Fig. 162; this prevents oiling up and also tends to lessen the risk of pre-ignition.

Fig. 164[1] shows the correct method of installing a plug in a high-performance engine. Here the gasket (1) is flattened and tight so as to prevent gas leakage. There are no exposed threads at (2), whilst the sparking points are on a level with the cylinder walls. Fig. 165 illustrates some incorrect points in sparking-plug installation. Here the copper-asbestos gasket has not been tightened sufficiently to form a gas-tight joint. Further, there is part of the cylinder-hole thread exposed at (2), so that a local " hot spot " may form. The plug points (3) are slightly below the surface,

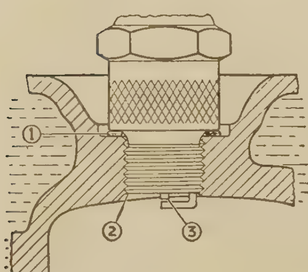


Fig. 164.—Illustrating Method of Fitting Sparking Plug in High Performance Engine.

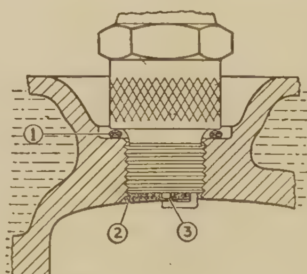


Fig. 165.—Wrong Method of Plug Installation.

[1] Champion Sparking Plug Co., Ltd.

also, but if the plug were tightened down correctly the points would project into the combustion chamber and would probably run too hot.

The Sparking-plug Electrodes

The modern sparking plug is so reliable that it will continue to work efficiently for long periods.

The sparking electrodes, however, must gradually wear away, so that the gap increases progressively. It is therefore necessary to examine the gap clearance from time to time—say, every 2,000 to 3,000 miles of road running.

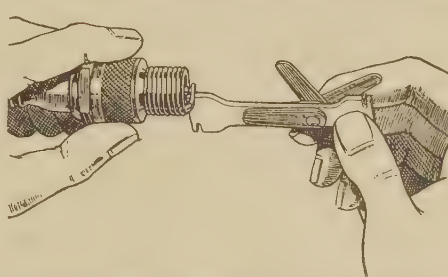


Fig. 166.—Showing Sparking-plug Gauge Tool in use for Setting the Gap (Morris).

It is essential to use the correct feeler gauge for checking the gap between the plug electrodes. The use of a visiting card or the method of guessing the gap distance are quite inadmissible; the feeler gauge is the only satisfactory practical method. Most car manufacturers include a contact-breaker and plug-gap gauge in the tool kit of new cars. Measurements should be made to the nearest two thousandths of an inch with an ordinary feeler gauge.

Fig. 166 shows the modern sparking-plug and contact-breaker gap gauge, which are combined with a special tool for setting the gap by bending the plug metal shell electrode. On no account should the central electrode be bent to set the gap. The correct gap for Morris engines (1951) is ·018 to ·022 in. If the electrodes are pitted badly, make sure that the correct gap reading is used when setting the plug points; in some cases the surface may be lightly trimmed with a fine file before setting the gap.

Fig. 167.—K.L.G. Plug Components

The Correct Plug-point Gap

Although it is generally assumed that the sparking-plug gaps are the same for all *magneto-ignition engines*, this is not actually the case. Different designs of engine require different plug-point gaps.

Thus, in the case of sparking plugs with heavy electrodes, the gaps recommended by a leading firm of manufacturers for magneto-ignition engines are:

(1) High-compression (7:1 to 8:1) engines	·011 to ·013 in.
(2) Medium-compression (6:1 to 6·5:1) engines	·012 to ·015 in.
(3) Low-compression (5:1 to 5·5:1) engines	·016 to ·018 in.

For coil-ignition systems, where a good spark is obtained at lower engine speeds than with magneto ignition, rather wider gaps can be employed.

In this connection the recommended gaps lie between ·018 and ·025 in. for normal H.T. coil systems. The actual value depends also to some extent upon the make or design of sparking plug, and in this connection the plug manufacturer's or engine manufacturer's recommendation should be followed, since engines differ in regard to engine compression ratios and temperatures, so that a plug that is suitable for one make of engine may not be satisfactory on another make.

An analysis of modern light-car-engine plug gaps shows that these lie between ·020 and ·024 in.

For high-voltage coil systems, a much wider gap can be employed, namely from ·032 to ·040 in., as there is an appreciably higher voltage given to the plug central electrode. Most American car engines now employ this wider plug gap and several British makes have adopted it. It is therefore important to ascertain what type of H.T. coil is fitted to any engine before adjusting the plug gaps in cases where the maker's recommended values are not known.

Sparking-plug Appearance and Condition

An examination of the sparking plug after its removal from the engine will give a fairly reliable indication of the operating conditions.

If the ceramic type of plug, now so widely used, shows an *ashy white appearance* this signifies that the plug has been *overheated*, and the cause should be looked for amongst the following possible ones: (1) *incorrect plug design used;* (2) *engine overheating due to too weak a mixture;* (3) *ignition too much retarded;* (4) *partial failure;* (5) *insufficient water in cooling system.*

If the insulator shows *a dry, shiny black appearance* this indicates too cool a plug, so that the temperature is insufficient to burn off the carbon deposit. The latter is due probably to too rich a mixture, as when the carburettor choke has been in frequent use.

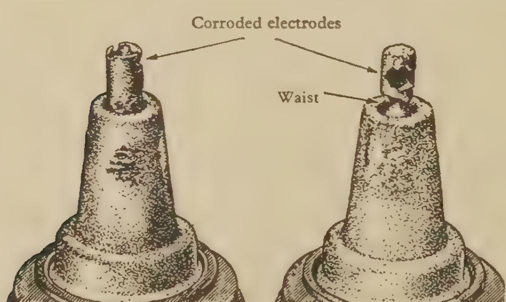


Fig. 168.—Effect of Leaded Fuels on Sparking Plugs.

If the insulator exhibits *a wet, shiny black appearance* one may conclude that *oil fouling* is the cause. This will probably be due to worn piston rings and cylinder walls allowing too much oil to escape into the combustion chamber. Unburnt oil will usually be found on the metal shell also. When the correct design of plug is used and the ignition and carburation conditions are correct, the insulator should have *a light-brown colour.*

When *leaded or high-octane fuels* are used there is an increased tendency towards corrosion of the electrodes. During combustion the lead element

in the fuel becomes lead oxide, which is a solid, and some of this compound, together with lead sulphate, forms a deposit on the insulator and metal of the plug. As this yellowish-brown coating is a conductor of electricity the plug finally becomes short-circuited through this coating, and no spark occurs at the plug electrodes.

After much service under leaded fuel conditions the electrodes become corroded in the manner shown—from actual examples—in Fig. 168. It will be noted that the corrosion takes the form of a " waist " on the top of the insulator. A cool plug is recommended for engines that run on leaded fuels. Inspection and cleaning of the plugs should be carried out at more frequent intervals, say every 1,000 to 2,000 miles, than when non-leaded or lower-octane fuels are used.

Auto-ignition and Pre-ignition

Two combustion troubles sometimes traceable to sparking plugs are (1) *auto-ignition of the fresh cylinder charge*, and (2) *pre-ignition of the charge.* Although both effects are similar in origin there is a definite difference between them.

Auto-ignition is the term usually applied when a modern petrol engine continues to operate after the ignition has been switched off. It is caused by a small piece of metal or carbon deposit protruding into the combustion chamber becoming red hot during combustion. Thus when the ignition is switched off, no spark occurring at the plug, the " hot spot " in the combustion chamber continues to ignite the fresh charges at about the correct time in a similar manner to the hot-bulb oil engine. The hot spot is thus maintained at a temperature well above the ignition part of the charge. The usual source of such a hot spot is a sharp edge of metal, such as a machining burr or sparking-plug thread. Another known cause is the *overheating of the plug points*—usually due to the incorrect design of plug or wrong installation, so that the points protrude into the combustion chamber. The remedy in this case is a change of plug or plugs to a type of the correct heat range.

Pre-ignition is also self-ignition of the charge by a local hot spot, but in this case the local source of heat is of greater intensity and ignites the charge earlier than the ignition spark does, or would do. This premature or pre-ignition effect actually occurs whilst the piston is moving towards the end of its compression stroke, so that the general effect is to create a retarding gas pressure on the piston. After a few strokes at the most the progressively earlier and earlier " explosions " will stop the engine, whereas with auto-ignition the engine continues to operate.

Pre-ignition is quite distinct from *detonation*, or pinking, which is purely a combustion phenomena dependent upon the constituents of the fuel, the compression pressure and temperature, combustion chamber design, etc.

Maintenance of Sparking Plugs

Usually, the modern design of sparking plug needs little attention until the car has done several thousand miles. When the engine and plugs are new, however, after the first 500 to 700 miles the plugs should be examined, since there is often an excess of oil, and over-rich starting mixtures may cause a deposition of carbon deposit on the plug insulators. This will not occur again for a long period, after the plugs have been cleaned and the engine has been run in and fresh oil introduced.

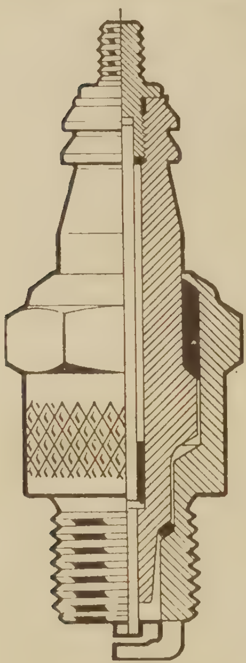


Fig. 169.—The Champion Sparking Plug.

In the course of time, owing to the erosive electrical conditions to which the electrodes are subjected, the points wear and the gap increases progressively, so that it is necessary, every few thousand miles, to check the gap and to reset it with the aid of a sparking-plug gap gauge.

Fig. 169 shows the Champion L10 extra-range sparking plug which is used on Morris and various other modern engines. This is of the single-pointed pattern.

The correct gap for this plug is ·018 to ·022 in.

If the gap is any wider this will tend to cause misfiring, especially at high speeds and large throttle openings.

If the gap is too small, it is more readily bridged with oil, fuel (as when starting from the cold), and carbon. Poor idling and difficult starting are often due to this cause.

The insulator should be kept clean at all times. It usually tends to receive a deposit of oil vapour or dirt, and this causes a surface leakage of electricity, which reduces the spark intensity at the plug points. In damp weather it tends to render starting more difficult.

After cleaning the insulator it should be examined for cracks. If such cracks are located it is advisable to scrap the plug and replace with a new one as trouble will occur sooner or later.

When cleaning the electrodes, insulation, and interior of the metal shell it is a good plan, before commencing to scrape off the deposits, to soak the plug in petrol, paraffin, or a chemical decarboniser liquid of the type sold for decarbonising cylinders. A suitably shaped sharp-edged wire scraper can readily be made for cleaning off the carbon.

When setting the gap of a sparking plug, whether of the single- or multiple-point type, always bend the electrodes attached to the metal shell and *never attempt to bend the central electrode* that passes through the insulator.

Care and Maintenance of Lodge Plugs

These plugs can be dismantled for cleaning by the method illustrated, graphically, in Figs. 170 and 171.

Hold the plug in a vice (Fig. 170) and unscrew the nut gland by means of a box spanner. Wash the surface of the inside insulation clean of soot and carbon, using petrol for this purpose. The surface should only be wiped carefully with a rag (Fig. 171) and must not be filed or rubbed with emery or glass paper.

Scrape the metal body quite clean of carbon, and, if desired, wash in paraffin or petrol. Reassemble the plug, using only sufficient force on the gland nut to make the joint gas-tight. After assembling the plug adjust the gap of the points to ·018 in. (or roughly the thickness of a visiting card).

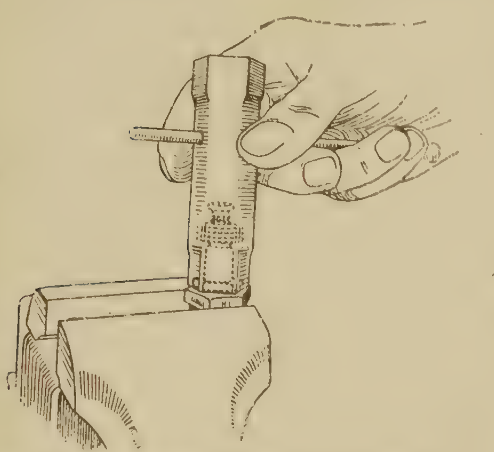


Fig. 170.—Dismantling the Lodge Plug for Cleaning.

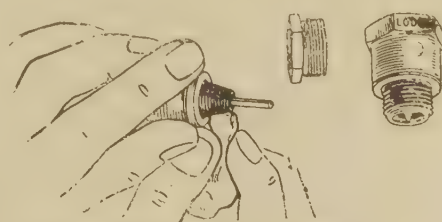


Fig. 171.—Cleaning off the Soot or Carbon Deposit.

The smaller 12-mm. and 14-mm. plugs are serviced in a similar manner to the ordinary 18-mm. ones, but, being rather more fragile, should be treated accordingly.

Fitting Sparking Plugs

Before fitting a new or reconditioned plug make certain that the thread in the cylinder hole is clean. Use a piece of cloth moistened with paraffin to clean both the plug and hole threads. The plug should screw down freely by hand.

Use a new gasket to ensure a proper gas-tight joint.

Do not screw the plug down too tightly or the plug may be distorted or the insulation cracked. This instruction is particularly concerned with the smaller 12-mm. and 14-mm. plugs, which have largely replaced the 18-mm. type that had such a long period of usage.

The correct torque wrench reading for 18 mm. plugs is 40 to 45 lb.-ft. For 14 mm. the reading should not exceed 33 to 37 lb.-ft., whilst for 10 mm. ones it should lie between 18 and 20 lb.-ft.

A box spanner should always be used for insertion and removal of sparking plugs. Not only is it more convenient than a set spanner, but there is no risk of damaging the insulation as with the latter type.

When to Replace Sparking Plugs

The modern high-compression, high-temperature engine imposes greater working stresses and erosive action on sparking plugs than hitherto, and although sparking-plug design and materials have been much improved it is inadvisable to operate a set in an engine too long, or unreliable running and increased fuel consumption may result.

Although it is possible, in the writer's experience, to run sparking plugs in a fairly modern engine for periods of 15,000 to 20,000 miles if

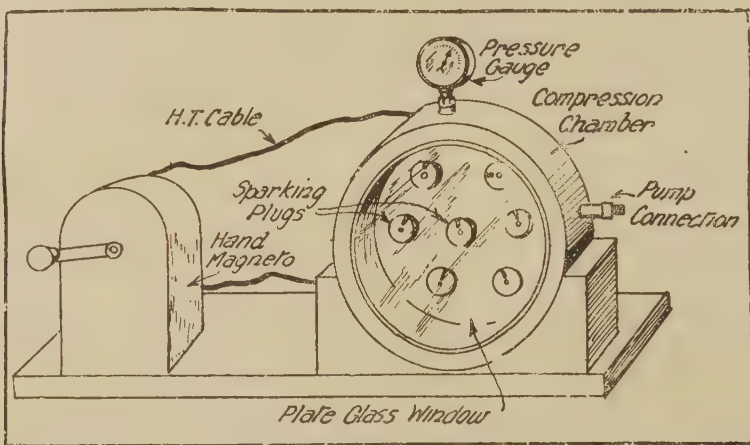


Fig. 172.—A Useful Sparking-plug Testing Equipment.

the plugs and engine are fully maintained or serviced all the time, yet experience indicates that it is inadvisable to use any set of plugs in a modern engine beyond 10,000 to 12,000 miles.

Very often it is found that the substitution of a new set of plugs will restore some of the lost power, reduce the fuel consumption, and give smoother running. Apart from this, it will obviate the risk of road trouble due to unreliable plugs.

Sparking-plug Tester

For garage work it is best to rig up a sparking-plug tester, consisting of a hand-operated magneto similar to the type used for starting aircraft engines, and to screw the plugs into a closed metal cylinder—a casting is generally the best for this purpose. A plate-glass window is fitted to

the other end so that the plug points can be observed. The air in the cylinder is then put under compression, with an ordinary tyre inflator, and the plugs are tested for ignition at 80 to 90 lb. per sq. in. pressure (Fig. 172).

For more accurate results, the three-electrode tester shown in Fig. 34 on page 36 should be used.

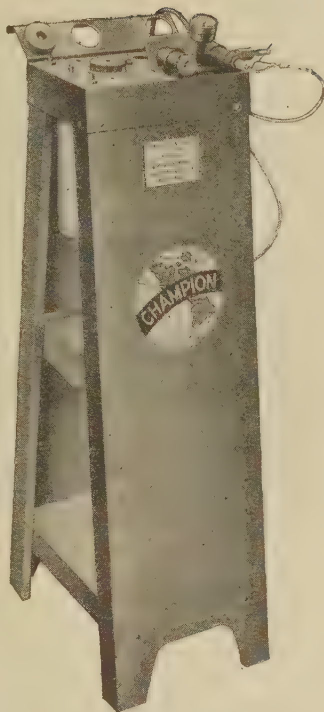


Fig. 173.—The Champion Plug Cleaning and Testing Plant.

Sparking-plug Cleaner and Tester Plant

A more recent sparking-plug cleaner and testing plant for garage use is that of the Champion Sparking Plug Co., Feltham, Middlesex, which is shown in Fig. 173. It employs an abrasive compound which is projected by a compressed-air supply on to the dirty surfaces of the plugs, whereby all carbon and hard, oily deposits are readily removed, as illustrated in Figs. 174 and 175.

The servicing procedure recommended is a follows: The plugs removed from the engine are placed with the electrodes uppermost in a special tray having holes in its horizontal surface for the purpose. Each plug is placed in a hole and its gasket retained in place. A new plug is placed alongside in order to compare the appearance of the engine plugs with it (Fig. 176).

Fig. 174.—Dirty Plug before Servicing.

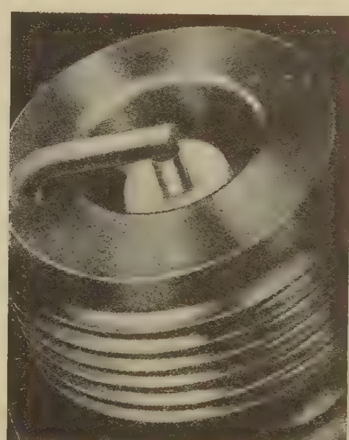


Fig. 175.—The same Plug after Servicing.

Before placing the plugs on the Champion cleaner, *the gaskets should be removed and inspected* and any defective ones replaced. Defective gaskets include those over-flattened, pitted on the bearing surfaces, blackened on part of the surface, etc.

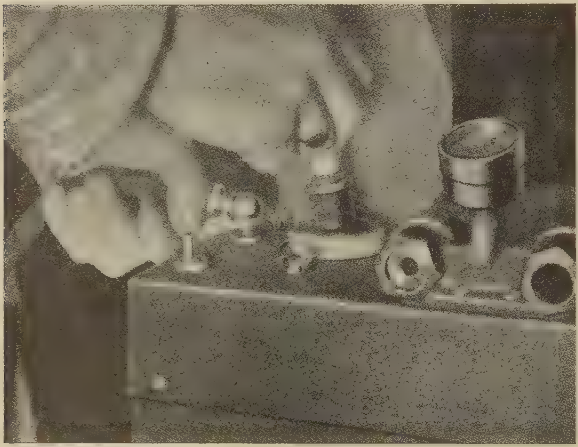


Fig. 176.—Cleaning the Plug. Turning on the Air Supply.

The plugs are then fitted with rubber adapters supplied with the plant and are cleaned with the abrasive air jet as explained in detail in the instruction booklet issued with the plant. Badly carboned plugs should have most of the carbon removed with a hand scraper before placing in the cleaner. After abrasive cleaning the plain air jet is used to blow out any particles of carbon or abrasive left in the plug.

After cleaning, the plugs should be carefully inspected for *cracked insulators* and if any are found these plugs should be scrapped.

After this, *the threads on the shell* should be cleaned of carbon deposit, using a wire brush for the purpose (Fig. 177). A wire buffing wheel can be used if proper care is exercised so as not to injure the insulators.

Fig. 177.—Cleaning the Plug Thread.

The cleaned plugs should be tested in the cylinder block to ensure that they will screw up tightly when their gaskets are in position.

Before replacement the electrode gaps should be measured with a feeler gauge and if necessary reset, *by bending the electrode attached to the metal shell* to ·022 in. for Champion plugs used with the ordinary (not the high-voltage) H.T. coil-ignition system.

The plugs are then placed in the cleaning and testing plant and checked for leakages by applying air pressure up to 100 lb. per sq. in. and applying

oil around the possible leakage regions, e.g. the insulator joints (Fig. 178). If satisfactory each plug is finally *tested for sparking*, by connecting it to the H.T. cable of the tester, pressing a push button on the latter and observing the reflected image of the electrodes in the metal mirror of the tester. The air pressure should be raised to about 100 lb. per sq. in. during the test, and for a satisfactory plug the sparking should be continuous (Fig. 179).

Fig. 178.—Testing for Gas Leakages by the Oil Method.

Neon-tube Tester

A method of checking whether the sparking plug is operating satisfactorily within the combustion chamber is to hold the metal electrode of a neon-tube tester against the terminal of the plug whilst the engine is running. If the neon tube glows effectively this is a sign of a good spark at the plug points,

Fig. 179.—Testing the Plug after Cleaning and Resetting Electrode Gap.

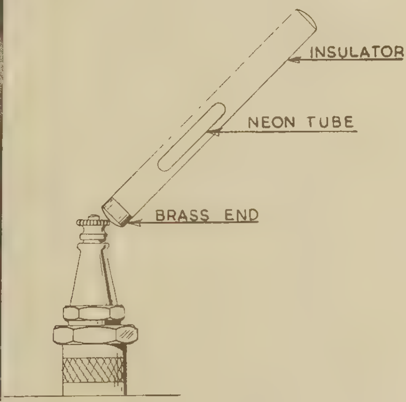


Fig. 180.—Neon-tube Plug Tester.

but if it exhibits a weak or irregular glow this is an indication of weak or irregular sparking at the plug points.

Instead of using the pencil-type neon-tube tester (Fig. 180) a special neon-tube terminal can be screwed to each sparking plug; with this pattern the operation of all the plugs of a multi-cylinder engine can be observed very readily.

A multi-engine plug indicator for dashboard fitting has been made having as many neon tubes as the engine has sparking plugs, with connec-

tion cables to each of these plugs. By this means the operation of all the plugs can be seen at all times.

Useful Plug-detacher Tool

The K.L.G. Quick-Detacher tool illustrated in Fig. 181 renders the removal and dismantling of sparking plugs an easy matter. It consists of an ordinary box spanner and tommy-bar. On one end there are two discs—one firmly affixed to the box spanner and containing eight holes. The other disc with nine holes can be rotated by leverage with the tommy-bar. The centres of the discs are, of course, cut to take the sparking-plug gland nut and the hexagon on the body, respectively.

Fig. 181.—The K.L.G. Sparking-plug Dismantling Tool.

The tool in question avoids the necessity for a vice and also obviates any possible damage to the plugs.

Useful Garage Plug Cleaner

Fig. 182 illustrates a convenient form of sparking-plug cleaner suitable for motor garages where the cleaning of such plugs is a routine process.

This cleaner also utilises the sand-blast principle of eliminating the carbon deposits inside the plug shell; it will also remove dirt or oil from the plug.

All that is necessary is simply to insert the plug into the screwed hole provided in the top of the apparatus and then to depress a lever controlling the compressed-air supply for a period of about 10 seconds. It will then be found that the dirtiest plug will be restored to a new condition.

Two models of this cleaner, made by Messrs. B.E.N. Patents, Ltd., London, are available. One of these has a tyre-valve type of compressed-air connection, whilst the other is intended for connection to a source of compressed-air supply by means of a steel pipe or rubber hose (Fig. 182).

Fig. 183 shows the A.C.-Sphinx sparking-plug cleaner.

The principle of the cleaner is that a special cleaning compound,

developed after some months' experimental work, and which *will not damage either porcelain or mica insulators*, is blown on to the plug through a hardened-steel nozzle set at a slight angle in order to clean the whole

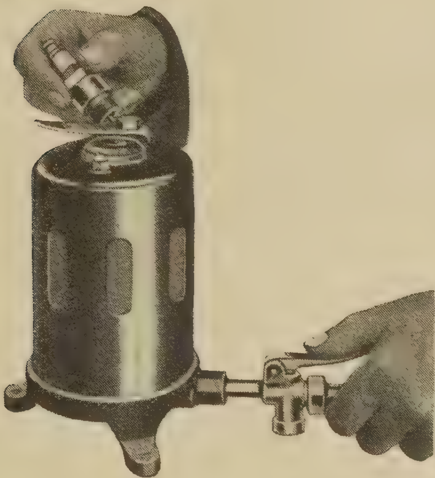


Fig. 182.—The B.E.N. Plug Cleaner.

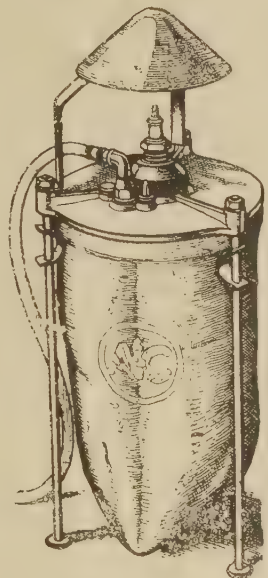


Fig. 183.—The A.C.-Sphinx Plug Cleaner.

length of the insulator instead of only the tip. By this arrangement the nozzle takes most of the wear, and a replacement is supplied with every refill package of cleaning compound sufficient for cleaning 200 to 500 plugs. The plug is first placed in an adapter and both are inserted at the top of the cleaner; the blast valve is then held down while the plug is slowly turned round. After removing the plug the remaining particles of compound or carbon are blown off it by a cleaning jet. Used compound and carbon are separated into an outer fabric bag, while the new compound is left in an inner container.

Platinum-electrode Sparking Plugs

A more recent design of sparking plug, representing the modern development of an early idea used on petrol engines, employs platinum or platinum-iridium alloy for the central electrode. It is well known that nickel electrodes on sparking plugs are subject to deterioration owing to the erosion of the metal at the sparking surfaces.

The K.L.G. platinum-electrode plug has one or each electrode made from platinum wire, capable of being raised to incandescence without oxidation and which is so thin that if raised to incandescence by the spark

discharge and/or by the heat of the burning gases in the engine cylinder, its capacity for heat is so small that it cools below incandescence immediately the next gaseous charge is introduced to the cylinder. In particular, the invention comprises a plug as mentioned in which one or each electrode is formed by a short length of thin wire made from platinum, or an alloy of platinum, such as platinum-iridium. The insulated central stem of the sparking plug has secured to it an electrode made from a short length of thin wire consisting of an alloy of platinum containing about 12 per cent. of iridium. If desired, pure platinum may be used, but the alloy is preferred. The projecting length of the wire is about ·10 in. and its diameter about ·02 in. The complementary electrode mounted on the body part of the plug may be of any ordinary form, or it may consist of another short length of thin wire like the insulated electrode.

Practical tests under exacting conditions have proved that this design of plug gives a very long service, improving starting and slow running; point burning is reduced to a minimum, whilst a bigger gap can be employed without misfiring taking place.

It is shown that whereas a nickel electrode is subject to pre-ignition at 700° C., a platinum one can be raised to 1,200° C. before it will cause pre-ignition.

These plugs are made in the 14-mm. and 18-mm. sizes with various reaches to suit different combustion-chamber designs.

Sparking-plug Threads

The common sizes of thread used are those of 14-mm. and 18-mm. external diameter. The form of the thread is not the 55° Whitworth one, but the 60° American or International one, with flat troughs and rounded crests to a depth of one-sixteenth of the height of the triangle. The pitch, or distance between consecutive threads, is 1·25 mm. for the 14-mm. thread and 1·5 mm. for the 18-mm. thread.

Sparking-plug Cables

These cables have to withstand very high voltages without leakage or breakdown and are usually of the heavy-rubbered pattern having 40 wires of about 32 S.W.G. tinned copper insulated with pure and vulcanised rubber. The overall diameter is usually 7 mm., but 9 mm. ones are also used.

More recently synthetic rubber has been employed instead of natural or vulcanised natural-base rubber, since it is both oil and petrol proof and will withstand higher operating temperatures, whilst being unaffected by atmospheric conditions.

CHAPTER 6

AUTOMOBILE ELECTRICAL CIRCUITS

THE complete electrical installation of a motor vehicle includes the various circuits and components as explained in Chapter I. Although the ignition, charging, starting, electric lighting, and accessories circuits are separate in their functions, in order to simplify the wiring and to economise material the various cables carry only " live " current, and the return circuit is provided by the metal of the engine and chassis. In earlier installations, using the two-wire or " insulated " system, there was a separate return insulated wire or cable from each component to the battery. It will be apparent that by using the common-earth return system only about one-half of the cables are required and the system is greatly simplified. In modern electrical systems further simplification is effected by using certain common " live " cables connected to the various terminals of a junction box conveniently located on the engine side of the dashboard. Thus instead of taking all " live " cables to the "live" battery terminal, a single cable is led to the junction, regulator, or fuse-box unit, and the other various "live" cables for the lighting, ignition, and accessories are all taken from this junction unit *via* their appropriate switches. Instead of having separate switches for each of the lamps, a single switch with different contacts is often used to switch on in one position the ignition and petrol gauge; next the side and tail lamps, and then the headlamps. The accessories, e.g. the horn, trafficators, windscreen wiper, etc., have their own separate switches, since they are used intermittently.

The Ammeter

In the majority of motor-cars and commercial vehicles an ammeter is fitted to indicate the value of the charging current supplied by the dynamo to the battery; also to show when the battery is actually discharging, as when the ignition or lamps are switched on when the engine is stationary or is running at too low a speed for the dynamo to commence to charge the battery. Motor-car ammeters are provided with dials which are graduated with a scale having a central zero mark, one-half of the scale being marked in ampere positive (charge) readings and the other in ampere negative (discharge) readings. The driver can therefore see whether the

battery is being charged or discharged. Under normal daylight running conditions the ammeter is a reliable indicator of the operation of the battery-charging system, i.e. the dynamo, cut-out, and regulator cables and connections.

The ammeters used with modern small and medium cars are graduated from −20 to 0 and on to +20 amperes. The usual maximum readings are from 14 to 17 amperes at dynamo speeds of about 2,000 r.p.m. For larger cars of the 12-volt type fitted with batteries of 60 to 75 ampere-hour capacity, the ammeter range is −30 to 0 to +30 amperes. The larger commercial vehicles are usually of the 24-volt system with two 12-volt batteries in series, the dynamos having maximum charging rates of 18 to 22 amperes at about 1,000 r.p.m. dynamo speed. The ammeter has a range of −30 to 0 to +30 amperes.

The starter-motor current, which may reach a maximum value of several hundred amperes, is not taken through the ammeter, since if an ammeter capable of indicating these heavy currents were used it would be useless for showing the ordinary charge and discharge current, on account of the very small part of the scale that would be used.

The Positive Earthing System

It has been mentioned elsewhere that the earlier method of connecting the negative terminal of the battery to the chassis frame, or "earth," has more recently been superseded by that of earthing the positive terminal, and it can be stated that this method has definite electrical and other advantages over the other one.

When the positive pole of the battery is earthed instead of the negative one, the central electrodes of the sparking plugs then become negative to the metal shells of the plugs, so that any corrosion or burning away of the plugs is confined to the relatively large area of the metal shell and not to the nickel-alloy central electrode, the plugs will last much longer on this account. Another advantage is that the metal tongue on the H.T. rotor arm of coil-ignition systems becomes negative to the metal contacts of the H.T. distributor casing to which the sparking-plug cables are attached, so that any burning away of the metal is confined to the relatively large-area metal contacts and not to the small-area metal tongue of the rotor arm; in negatively earthed systems the latter becomes burnt away and the jump-spark gap increases progressively.

When the positive pole of the battery is earthed it is also necessary to earth the positive pole connections of the dynamo and to reverse the ordinary ammeter connections of the negative-earth system. It is also possible to reverse the polarity of a dynamo designed for use with the latter system, using the battery for this purpose.

When the motor engineer is called upon to service earlier model cars or other motor vehicles he should first ascertain which battery pole is connected to earth.

Cables Used for Wiring Systems

The size of the conductor carrying electricity depends upon the maximum current value taken through it. If the current is a matter of a few amperes only, as in the low-tension ignition system and the cables that lead from the junction box to the separate lamps, etc., the copper wires are of small diameter and few in number. If, on the other hand, the current is heavy, as in the battery-starter circuit, a much greater area of conductor is required. The voltage, however, is relatively low, namely 6, 12, or 24 volts, so that the insulation need not be very thick. Where the voltage is high, e.g. in the high-tension ignition circuit, the insulation must be much heavier, otherwise the high-voltage current, although of very low amperage, will discharge to the metal parts of the engine or chassis near by.

In cases where cables are liable to chafe or fray they are provided with a strong external casing, e.g. heavy braid or metal armour casings. Similarly, provision must be made in regard to the insulation and its covering being petrol- and oil-proof and able to resist the effects of the engine heat under the bonnet. A further requirement is that, more especially in the case of H.T. cables, they will not perish or crack under the working conditions of temperature, vibration, oil, or petrol. A typical casing for low-tension cables that are subjected to severe working conditions is the *cab-tyre sheathed* (C.T.S.) one, which has a sufficient thickness of hard, tough, heat- and oil-resistant rubber.

The low-tension system cables, e.g. the dynamo and lighting circuit ones, have central conductors of tinned-copper wires from ·012 in. diameter upwards, the number of separate wires being dependent upon the maximum current that will be carried.

The following are some typical specifications:[1]

LOW-TENSION CABLE SPECIFICATIONS

No. of Wires	*Diameter of Wires*	*Area of Wires (total)*	*Overall Dimensions (diameters)*		*Current-carrying Capacity*
			Untaped	*C.R. Taped*	
	in.	*sq. in.*	*in.*	*in.*	*amperes*
9	·012*	·001	·160	·160	4·0
14	·012	0015	·165	·170	7·0
28	·012	·003	·190	·190	14·0
35	·012	·004	·195	·200	17·0
44	·012	·005	·205	·205	19·0
120	·012	·013	·310	·300	43·0

* Same as 30 B.W.G.

Single cables are coloured red, and twin cables in the same sheath red and black. Triple cables are red, black, and white.

Here it may be mentioned that automobile cables are specified by the

[1] Messrs. Aerialite, Ltd., Stalybridge.

numbers denoting their single-wire diameter and number of wires. Thus a cable indicated by 14/·012 denotes one having 14 tinned or plain copper wires each of ·012 in. diameter.

Starting-motor cables usually consist of 37 or 61 wires each of ·036 in. or ·044 in. tinned copper wire. These cables would be specified as 37/·036 or 61/·044 types. The conductors would be surrounded by vulcanised rubber. Over these covered conductors would be wound rubber-proofed tape with a layer of varnished cambric and, finally, an outer braided cover impregnated with a waterproofing compound.

High-tension cables are usually of the 40/·01 type, rubber covered with vulcanised high-grade rubber, the overall diameter being 7 mm.

A typical *low-tension cable* for battery-ignition circuits is the 30/·01 type with vulcanised indiarubber over which is braided cotton, glazed and waterproofed. The diameter is 4 mm. The smooth outer surface is here important. Usually it is black and resembles a sleeve, being so flexible that it does not crack when bent back on itself.

It may be mentioned that *low-voltage cables for automobiles* are now standardised, full particulars for these cables being given in the Institution of Automobile Engineers (I.A.E.) Data Sheet No. 192 R.[1]

When cables are exposed to severe mechanical or chafing conditions, *metal armouring*, consisting of a close spiral of flexible and non-corrodible wire of half-round section, not less than ·015 in. thick, is used over the outer covering of varnished cambric tape.

The Fuses

In order to protect the various electrical components in motor vehicles it is necessary to fit fuses in each of the main or important circuits, for a similar reason to that of domestic lighting-circuit fuses, namely, to confine the effects of excessive currents to "blowing" the fuse instead of burning out any of the electrical apparatus.

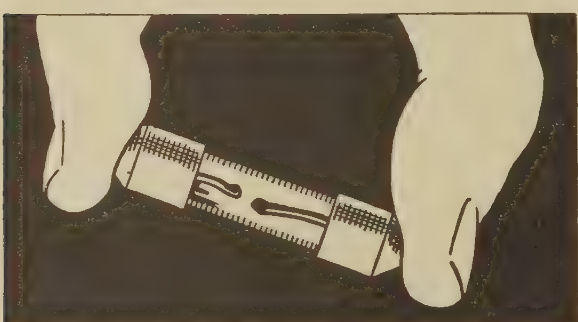


Fig. 184.—A Blown Fuse.

Although the various components, e.g. the dynamo, ignition apparatus, and the lamp-wiring systems, also employ wires or cables of sufficient size to take the full working currents, in the event of a break or short-circuit excessive currents may occur; it is the purpose of fuses to protect the circuits against such effects. The fuses used on automobiles are usually

[1] Automobile Division, Institution of Mechanical Engineers, London, S.W.1.

of the cartridge type, consisting of a length of very fine lead-alloy or similar wire having a fusing current value lower than that of the circuit or any of its electrical components in which the fuse is placed. The fuse wire is enclosed in a glass tube with nickel-plated brass end caps, to which the wires are soldered.

A blown fuse (Fig. 184) is indicated by the failure of all the units protected by it and is confirmed by an examination of the fuse itself; if it has blown, the fused ends of the broken wire will have the appearance illustrated in Fig. 184.

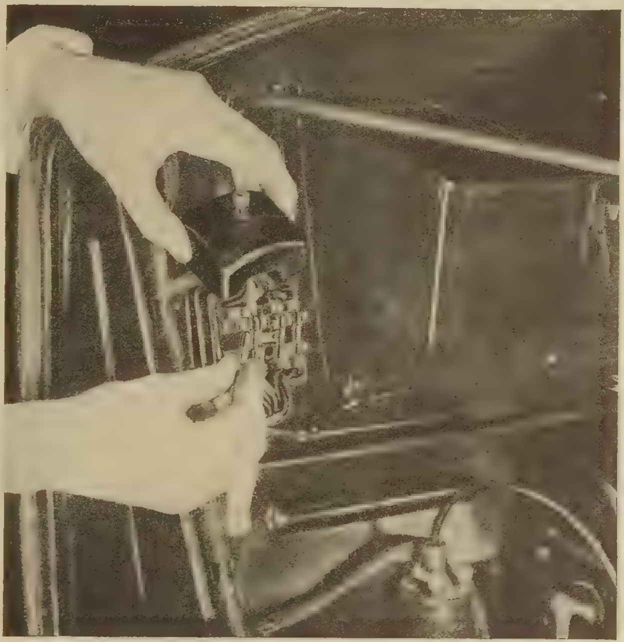


Fig. 185.—Replacing a Blown Fuse.

Before replacing a blown fuse inspect the wiring of the units that have failed, for evidence of a short-circuit or other sources of trouble; the cause of the trouble should be remedied before renewing the blown fuse with a new one of the same value.

To replace a fuse it is only necessary, after switching off the current, to withdraw it from its spring clips and then insert the new fuse in its place.

In most modern electrical equipments *spare fuses* are provided, usually inside the fuse box or combination fuse and junction box.

Other types of fuses as used on commercial vehicles are the *wire type* (Fig. 186) and *strip type* (Fig. 187). In the former the wire is mounted on an insulated bridge piece with a strand of tinned copper wire stretched between the spring contact clips. Spare wire is wound around the top of the bridge. When fitting a new fuse remove the old blown fuse pieces and slip one strand of wire into the clips.

Strip fuses consist of flat-shaped pieces of fuse material which are mounted in between two posts with spring-loaded insulated knobs to hold the strip in position. The value of the fuse is stamped on the ends of the strip, and replacement is effected by pulling up and turning the knobs indicated. Spares for this type of fuse are either mounted on posts or behind a spring clip inside the terminal cover.

The Lucas Type R.F.91 Unit

The type R.F.91 unit (Fig. 189) comprises the cut-out, regulator, and fuse box, and it is used on cars such as the Morris and Austin, and other

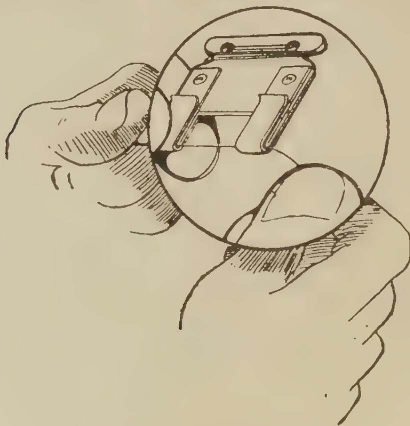


Fig. 186.—Wire-type Fuse.

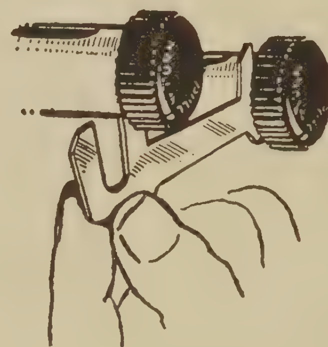


Fig. 187.—Strip-type Fuse.

makes. It houses the cut-out, dynamo voltage regulator, together with two fuses, and is mounted on the engine side of the dashboard.

The fuses incorporated in this unit protect the auxiliary accessories, e.g. electric horn, windscreen wiper, etc.

The cut-out, regulator, and fuses are protected by a moulded cover.

As supplied by the car manufacturers the cut-out and regulator are accurately set before leaving the Works and should not be tampered with.

The fuse marked "AUX" (Fig. 188) (25 amperes) protects the accessories which are connected so that they operate whether the ignition switch is "On" or "Off." The dynamo field circuit fuse shown is of 4·5 amperes rating.

The fuses marked "AUX IGN" (Fig. 189) protect the accessories which are connected so that they operate only when the ignition is switched "On," e.g. the stop lamp, fuel gauge horn, and trafficators,

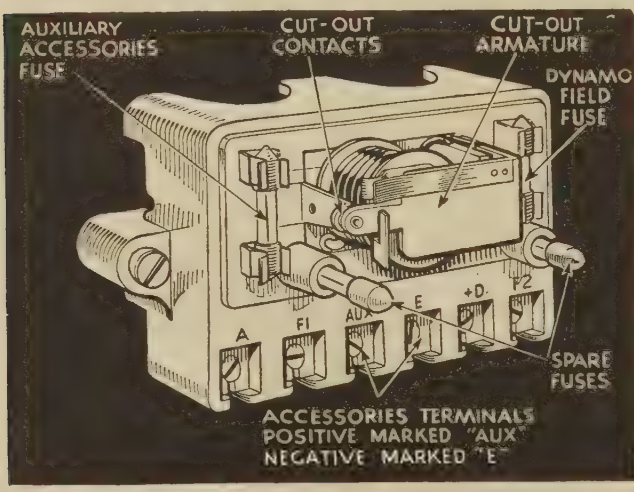


Fig. 188.—Morris Fuse-box and Cut-out Unit.

If any of the units fail, the fuse protecting them should be examined, and if found to have blown, the wiring should be examined for a short circuit; or the accessory windings themselves. The replacement fuse should be used only after the defect has been remedied.

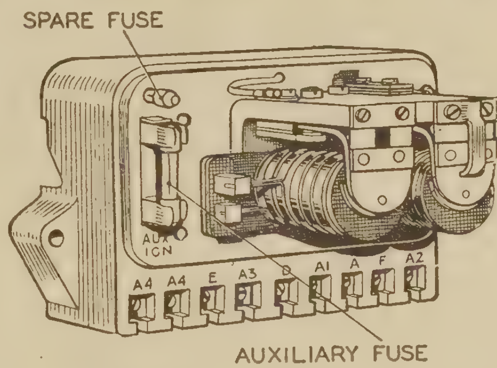


Fig. 189.—Lucas Combined Cut-out, Regulator, and Fuse Unit (R.F.71 and R.F.91 types).

Other types of combined cut-out, regulator, and fuse units, known more generally as *Control Boxes*, are referred to in Chapter 7.

The main fuses are usually of the 25-ampere type. When a separate dynamo-to-battery circuit fuse is fitted to medium-car dynamos, this is of 15-ampere fusing capacity. A piece of 29 S.W.G. tinned copper wire fuses at this value. For commercial-vehicle dynamos the fuses vary from 22 to 150 amperes, i.e. twice the maximum outputs.

Wiring-diagram Methods

The complete electrical wiring diagram of a motor-car and other vehicles enables every circuit to be traced on the one illustration instead of having separate diagrams for each of the individual systems, i.e. the starting, battery charging, lighting, ignition, and auxiliary electrical components circuits.

The methods employed by car manufacturers and electrical components supply firms differ to some extent from the multiple parallel line complex diagrams to the more simple widely spread and simply annotated ones.

In all cases of modern vehicles it is the custom to use *cables of different colours* and often with tracers to identify them and thus enable a given cable running from one connection on, say, the instrument panel to a remote part of the vehicle to be traced to its end connections without having to follow each cable individually throughout its length.

In a simple wiring diagram method that has been employed for motor-cars, the use of close parallel lines to represent cables was avoided by adopting the method illustrated in Fig. 190. This shows the various circuits for a six-cylinder engine car in a simple and easily understood manner. In this example no cable colours or designations are used.

Another example of a simplified wiring diagram is that of the Ford "Prefect" 10-h.p. car illustrated in Fig. 191. The main feature of this excellent diagram is that the various electrical components have been shown

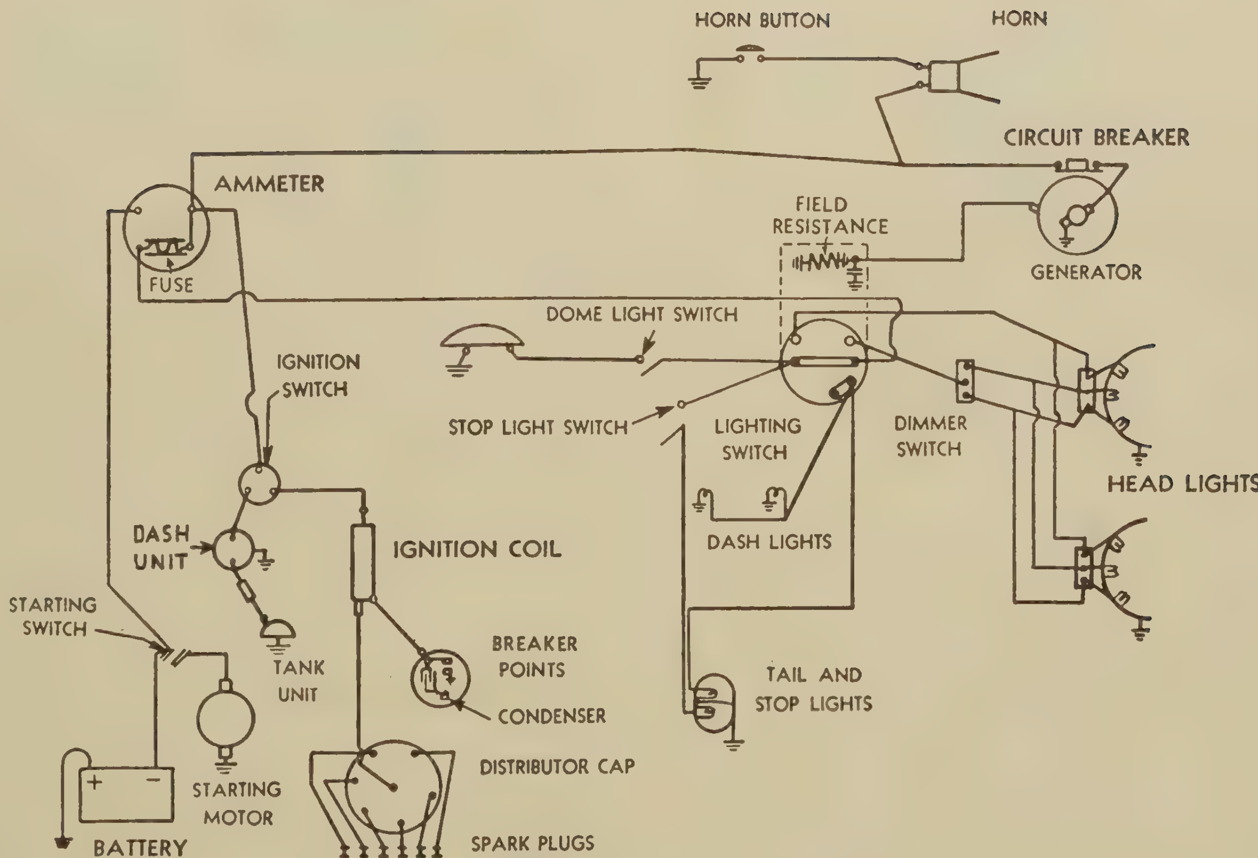


Fig. 190.—A Simple Type of Wiring Diagram for Six-cylinder Engine Car.

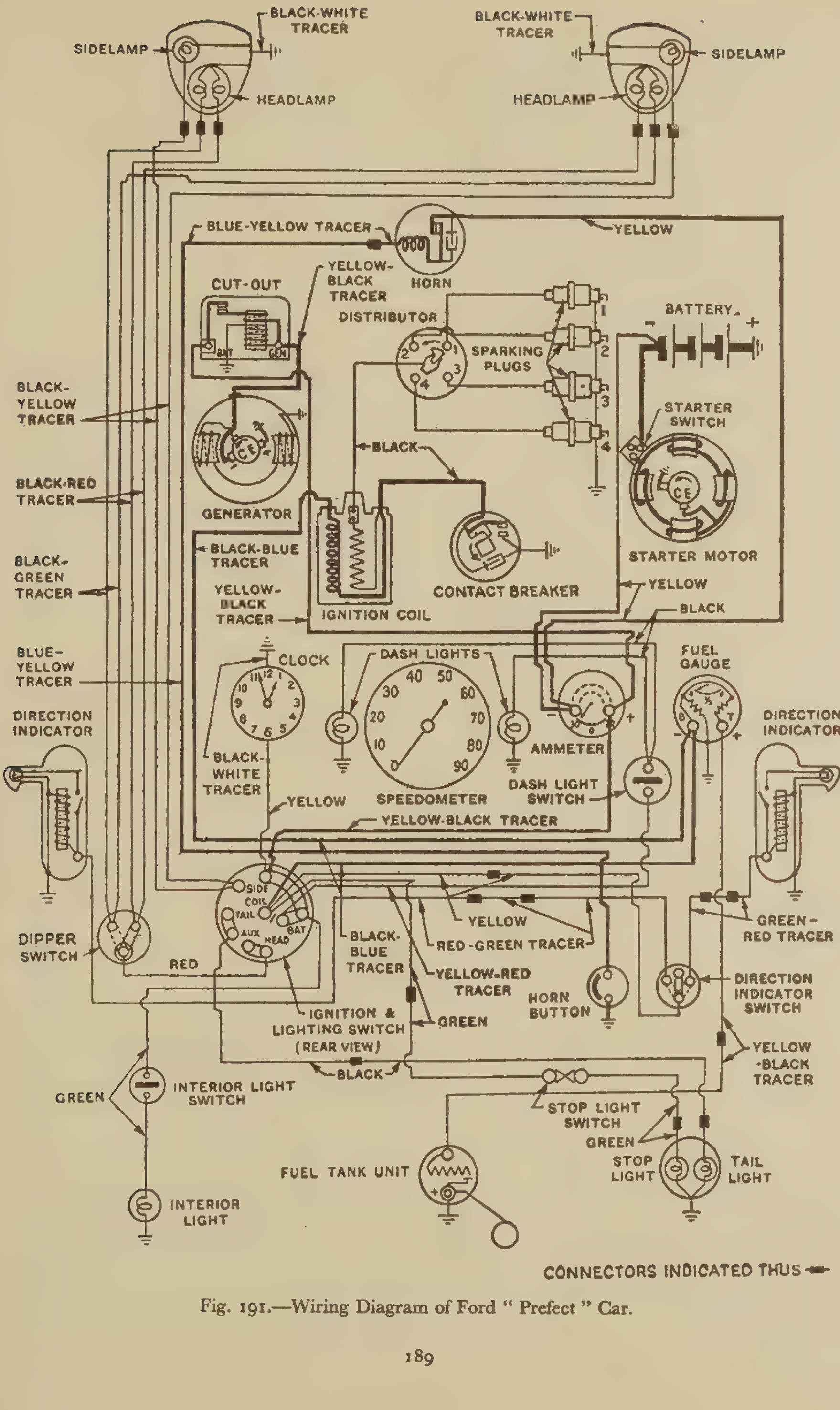


Fig. 191.—Wiring Diagram of Ford "Prefect" Car.

to a sufficiently large scale and in detail. Thus the actual wiring arrangements of most of the components, e.g. the dynamo, cut-out, H.T. coil, starting motor, fuel gauge, trafficator, and lamps, are clearly shown. If the reader, wishing to understand the wiring diagram, concentrates in turn upon the ignition, battery-charging, starting, electric lighting, and auxiliary circuits, he should not find it difficult to understand how to deal with this and more complicated diagrams.

It will be observed that the identification colours of the various cables are marked alongside them, so that when dealing with the actual wiring on the car, every cable can readily be traced to its end connections and, if necessary, to intermediate places.

It will be observed that the positive pole of the 6-volt battery is earthed and a single cable is taken from the negative (or "live") pole to one terminal, namely that marked "minus," of the ammeter. After flowing through the latter instrument the current is lead by the yellow-black tracer cables to (1) the battery terminal on the cut-out unit and (2) the combination lamp switch, the various positions of the arm of which operate the different lamps. It will also be noted that the "live" current for operating the trafficators (direction indicators) is taken from the battery sector of the same switch as is the current for the electric clock. The electric fuel-level gauge also receives its current from the same switch. The low-tension circuit of the ignition system is taken from the same "live" terminal *via* that marked minus (B) on the fuel-gauge instrument panel unit.

In regard to the battery-charging circuit, the dynamo supplies current through the black line indicated yellow-black tracer cable to the cut-out (generator terminal), whence it leaves by the battery terminal cable of the same colour to and through the ammeter, and thence *via* the yellow cable to the battery. The connection from the negative pole of the battery goes direct to the starter switch and thence, through the field and armature coils of the motor, to the earth-return brush connection. It will be observed that this circuit is independent of the ammeter, for the reason stated earlier in this chapter.

An example of a simplified wiring diagram of a typical American car, which is fitted alternatively with a six- or an eight-cylinder engine, is given in Fig. 192. Special features shown in the diagram include the instrument lights, panel upper-beam signal bulbs, twin electric horns, with alternative single horn, tail, stop and licence-plate lamps, electric petrol-level gauge (marked "gas gauge" and "gas tank unit") and the junction box, shown above. The reader should have no difficulty in tracing the various circuits.

Fig. 193 is an example of a modern car wiring diagram, namely that of the export model Austin A40. In this case the parallel line method is used to show the various cables, the latter being coloured as shown.

Cable Harness.—Where a number of different cables lead to different components in the same direction, they are usually grouped together in a common harness or casing; this avoids having to connect individual

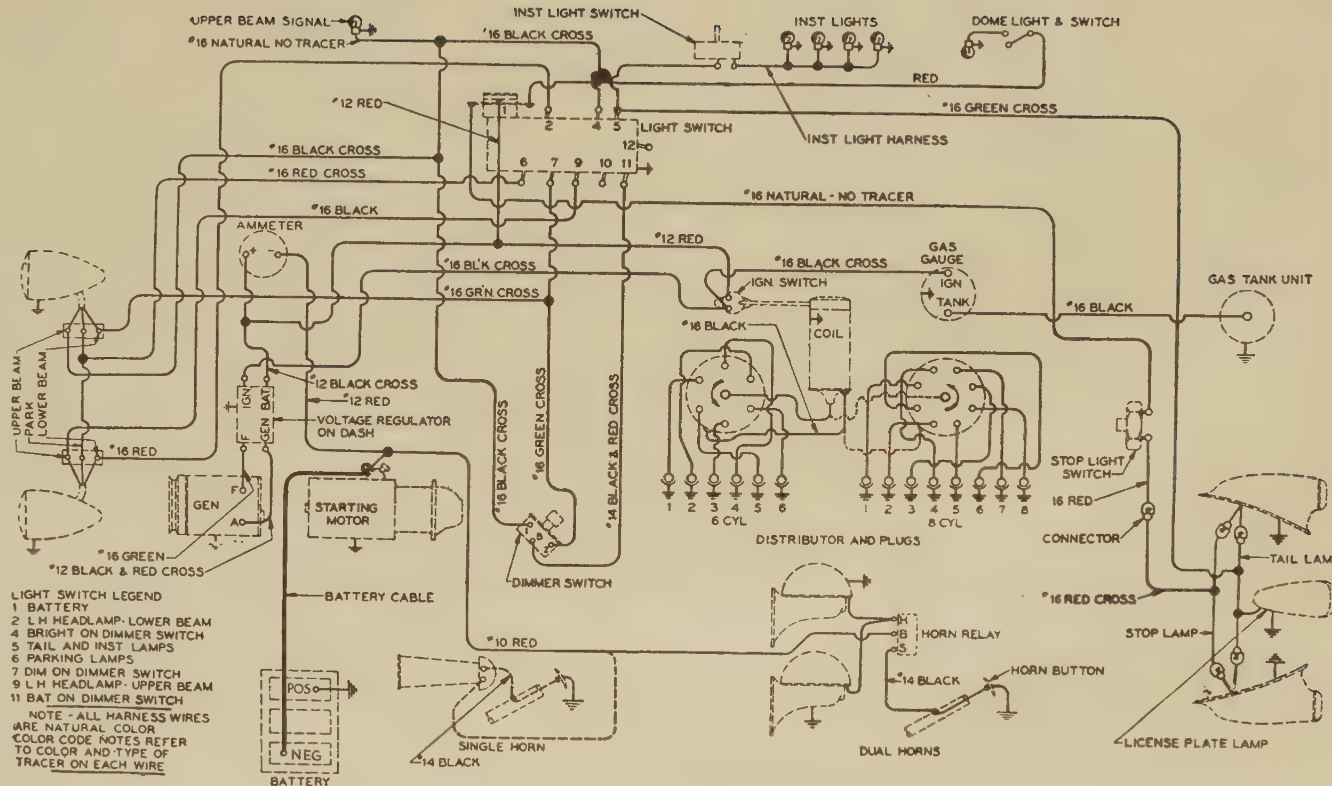


Fig. 192.—Wiring Diagram for American Car, using alternatively a Six- or Eight-cylinder Engine.

cables together, and results in a neat and compact wiring layout on the vehicle.

Referring to Fig. 199, the heavy black lines around certain groups

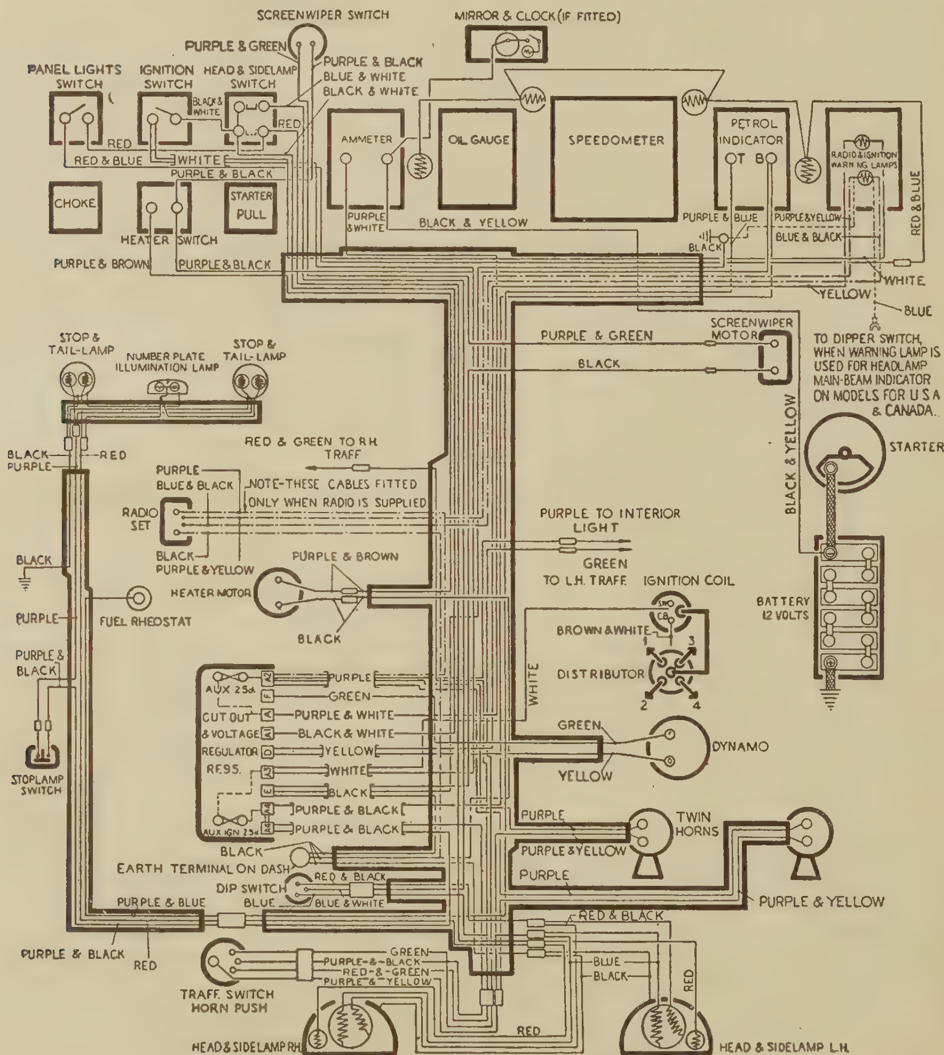


Fig. 193.—The Austin A40 Car Wiring Diagram, showing also Cable Harness Units.

of cables indicate that these are enclosed in harnesses. Thus the main central group of individual cables indicated by the fine vertical lines are all enclosed in a harness—shown by the heavy external vertical lines. Similarly, all cables going to the rear of the car, namely to the rear lamps

and petrol-tank unit, are enclosed in a single harness leading to the main central harness.

Some Other Wiring-diagram Methods.—An example of a wiring diagram showing in addition to the cable colours the *actual specifications of the various cables* is given in Fig. 194, which shows the Bedford Model OSS wiring layout (6-volt).

Perhaps the simplest modern method of identifying cables on complicated wiring diagrams is to use numbers alongside the various cables, and then to supply a key to the numbers and corresponding cable colours. This method gives a much clearer diagram that is easier to follow, since the numbers take up far less space than would be the case with cable colours.

A typical example of a modern car wiring diagram using cable numbers is shown in Fig. 195. This diagram refers to the export model Morris Oxford Series MO car. It uses the 12-volt battery system, Lucas two-brush dynamo, and R.F. 95 control box. The various circuits can readily be traced in this simplified wiring layout.

As a final example of motor-vehicle wiring diagrams, that of the A.E.C. "Mammoth Major" Mark III heavy goods vehicle will be considered. Fig. 196 shows on the left the wiring harness and cable diagram, whilst the right illustration is the simplified basic circuit diagram for the complete vehicle electrical system.

It should here be explained that the vehicle in question is fitted with a high-speed Diesel engine, and therefore requires no ignition system; nor does it require combustion-chamber heater plugs, as with certain other Diesel-engine designs. On this account, therefore, the wiring diagram is somewhat simplified. The electrical system shown in Fig. 196 is the 24-volt one with *insulated positive and negative* cables, no chassis earthed system being used here. This system obviates any risk of breakdown due to faulty earth connections at each of the components concerned; the liability to such a breakdown is greater for heavy commercial vehicles.

The electrical system employed is the Simms one, with Type DQ control unit and double filament headlamps. The dynamo employed is of the two-brush pattern, and is used in conjunction with constant-voltage control.

Further reference to the Simms DQ control unit is made later in this chapter, so that it is necessary only to point out that this control unit houses the cut-out, voltage regulator, the terminals for the various component cable connections, and the operating switches.

Commercial-vehicle Wiring Methods

There are four different wiring systems used on commercial vehicles, each with its attendant advantages and disadvantages. The system used depends upon the type of service, and whether of the oil, petrol engine, passenger, or goods vehicle. Most electrical supply firms, such as C.A.V., provide electrical components for each of these four systems.

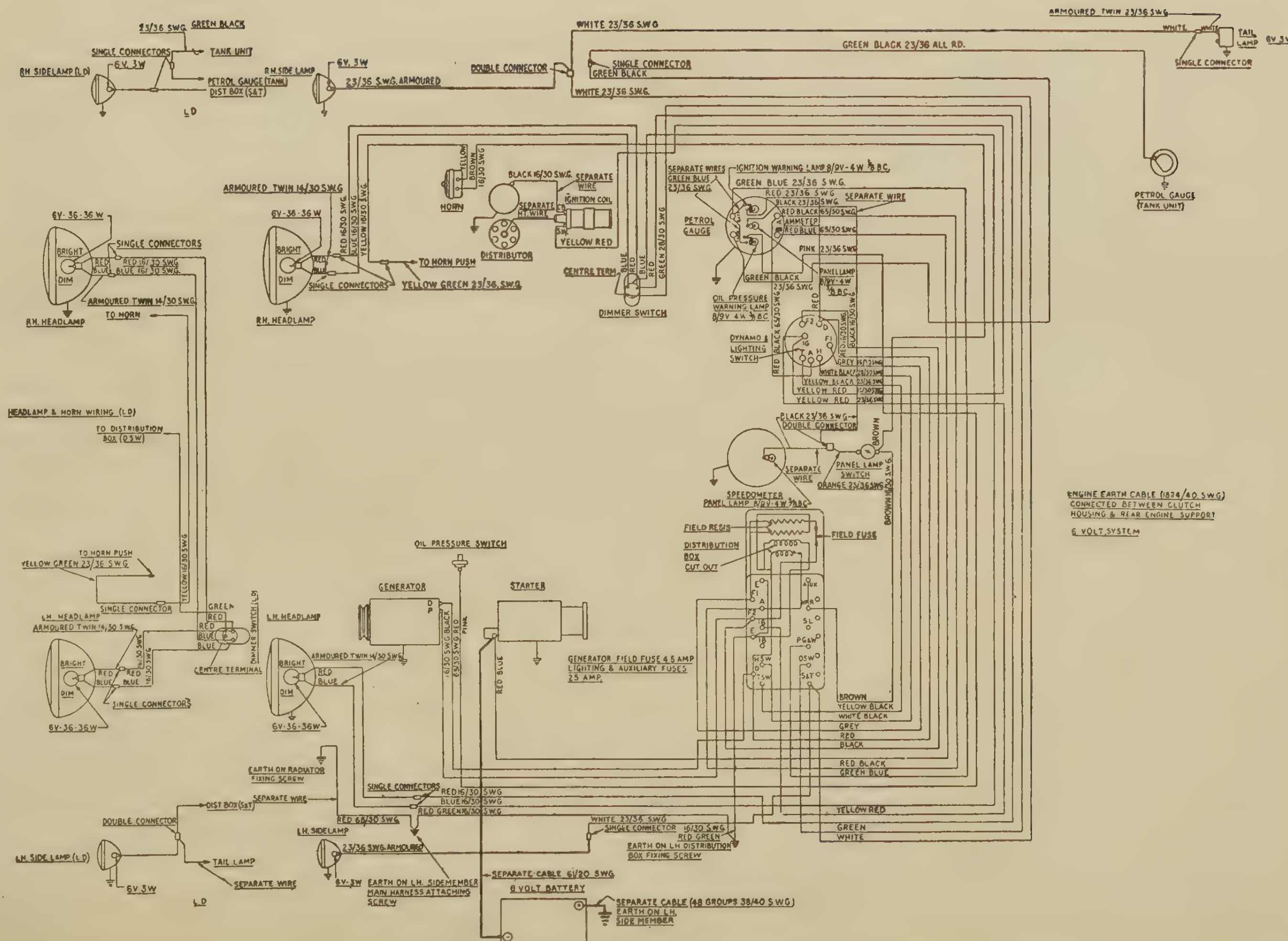
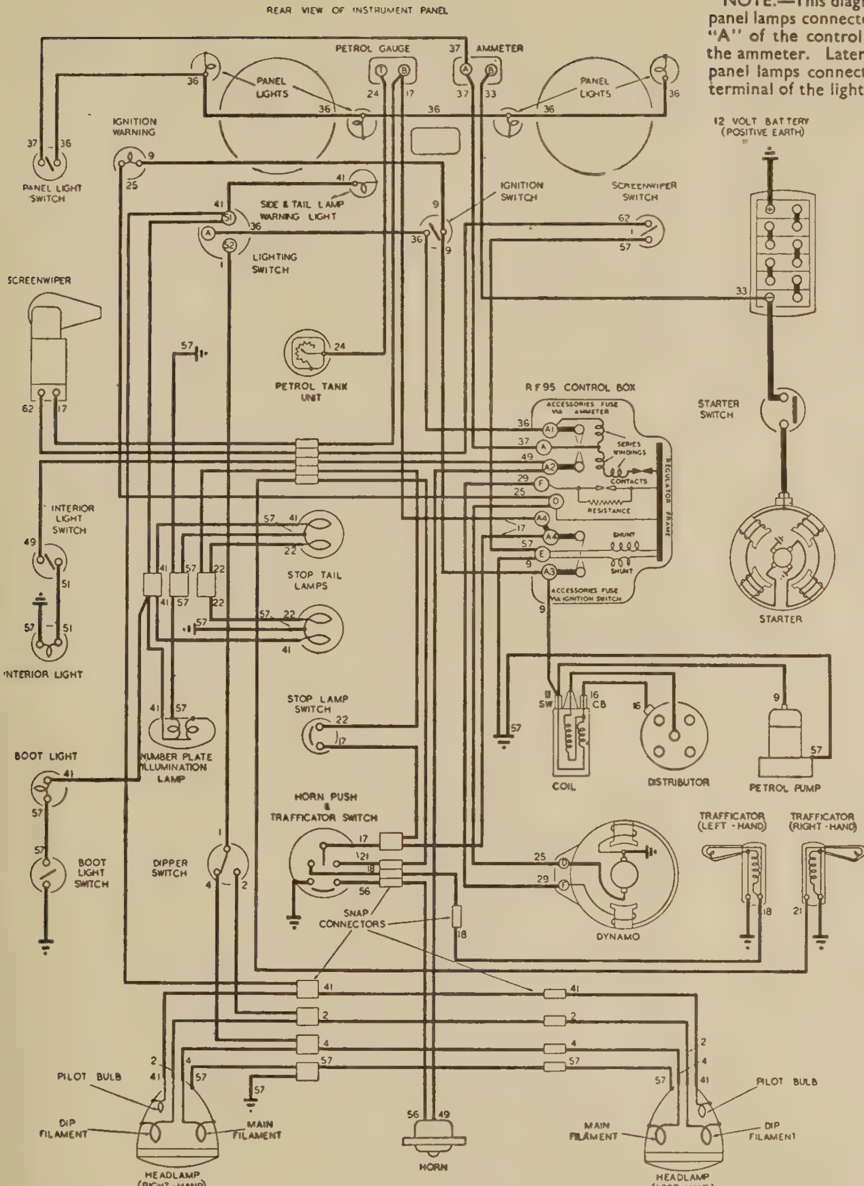


Fig. 194.—The Bedford Type OSS Vehicle Wiring Diagram.

NOTE.—This diagram shows the panel lamps connected to terminal "A" of the control box through the ammeter. Later cars have the panel lamps connected to the S.I. terminal of the lighting switch.



KEY TO CABLE COLOURS

1 Blue	14 White with Purple	27 Yellow with Blue	40 Brown with Black	53 Purple with White
2 Blue with Red	15 White with Brown	28 Yellow with White	41 Red	54 Purple with Green
3 Blue with Yellow	16 White with Black	29 Yellow with Green	42 Red with Yellow	55 Purple with Brown
4 Blue with White	17 Green	30 Yellow with Purple	43 Red with Blue	56 Purple with Black
5 Blue with Green	18 Green with Red	31 Yellow with Brown	44 Red with White	57 Black
6 Blue with Purple	19 Green with Yellow	32 Yellow with Black	45 Red with Green	58 Black with Red
7 Blue with Brown	20 Green with Blue	33 Brown	46 Red with Purple	59 Black with Yellow
8 Blue with Black	21 Green with White	34 Brown with Red	47 Red with Brown	60 Black with Blue
9 White	22 Green with Purple	35 Brown with Yellow	48 Red with Black	61 Black with White
10 White with Red	23 Green with Brown	36 Brown with Blue	49 Purple	62 Black with Green
11 White with Yellow	24 Green with Black	37 Brown with White	50 Purple with Red	63 Black with Purple
12 White with Blue	25 Yellow	38 Brown with Green	51 Purple with Yellow	64 Black with Brown
13 White with Green	26 Yellow with Red	39 Brown with Purple	52 Purple with Blue	

Fig. 195.—Wiring Diagram of the Morris Oxford (Series MO) Car.

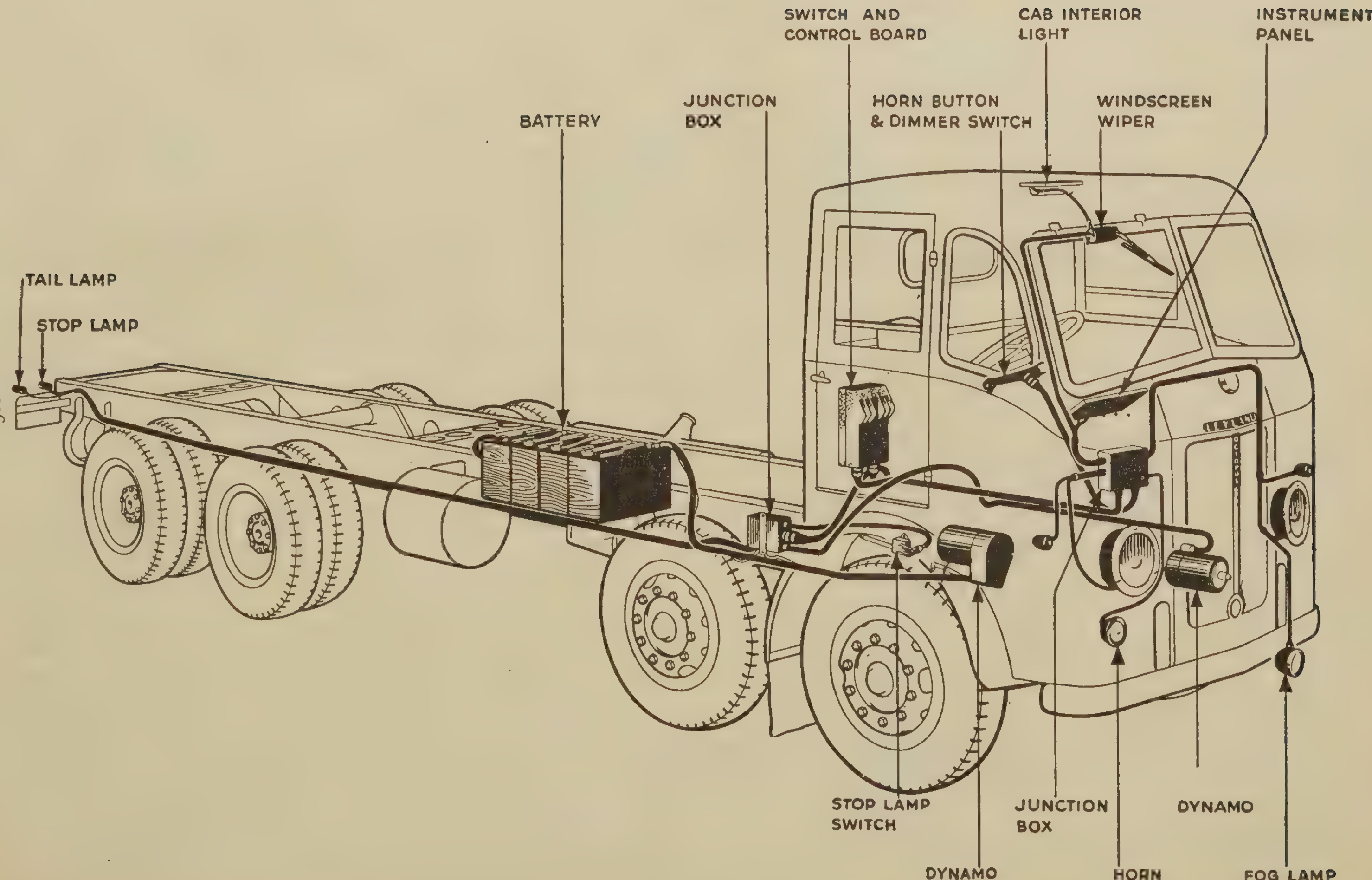


Fig. 197.—Showing the Layout of the Electrical Equipment in the Case of Leyland Commercial Vehicles.

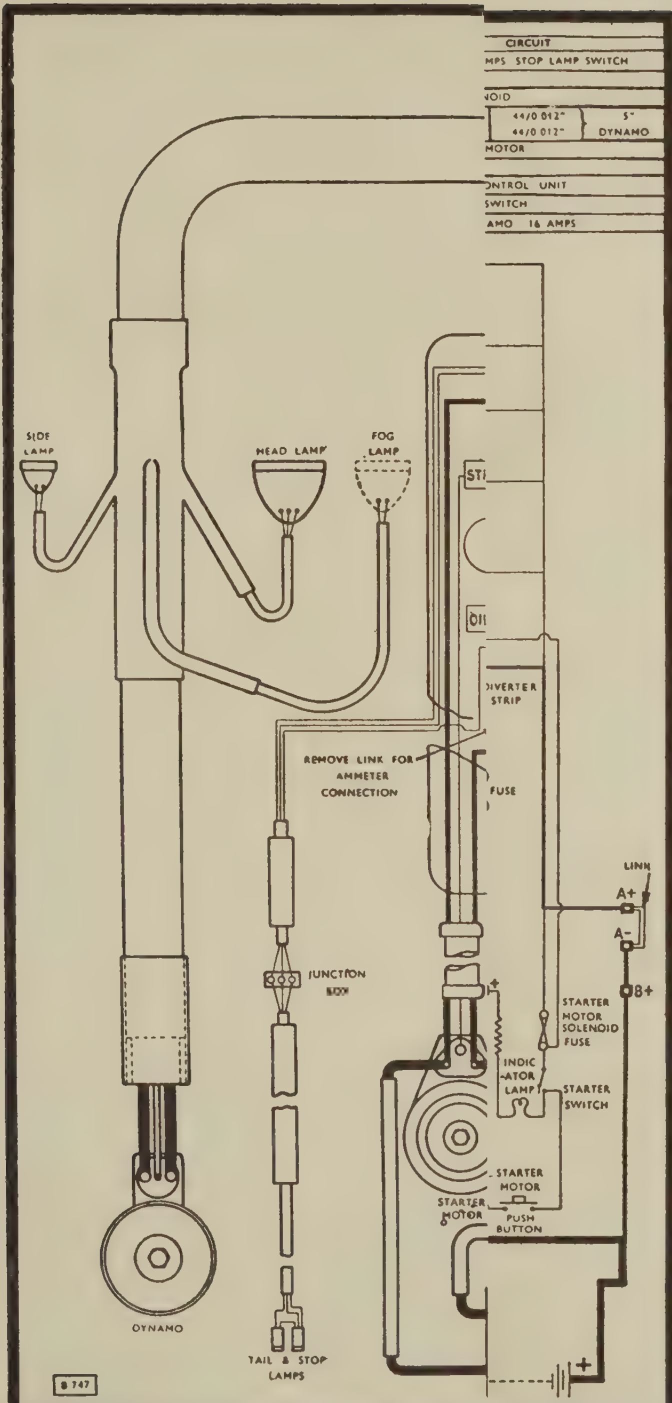

CIRCUIT
MPS STOP LAMP SWITCH
NOID
44/0 012"
44/0 012"
5"
DYNAMO
MOTOR
ONTROL UNIT
SWITCH
AMO 16 AMPS
SIDE LAMP
HEAD LAMP
FOG LAMP
DIVERTER STRIP
REMOVE LINK FOR AMMETER CONNECTION
FUSE
LINK
A+
A-
B+
JUNCTION
STARTER MOTOR SOLENOID FUSE
INDICATOR LAMP
STARTER SWITCH
STARTER MOTOR
STARTER MOTOR
PUSH BUTTON
DYNAMO
TAIL & STOP LAMPS
B 747

Fig. 19(

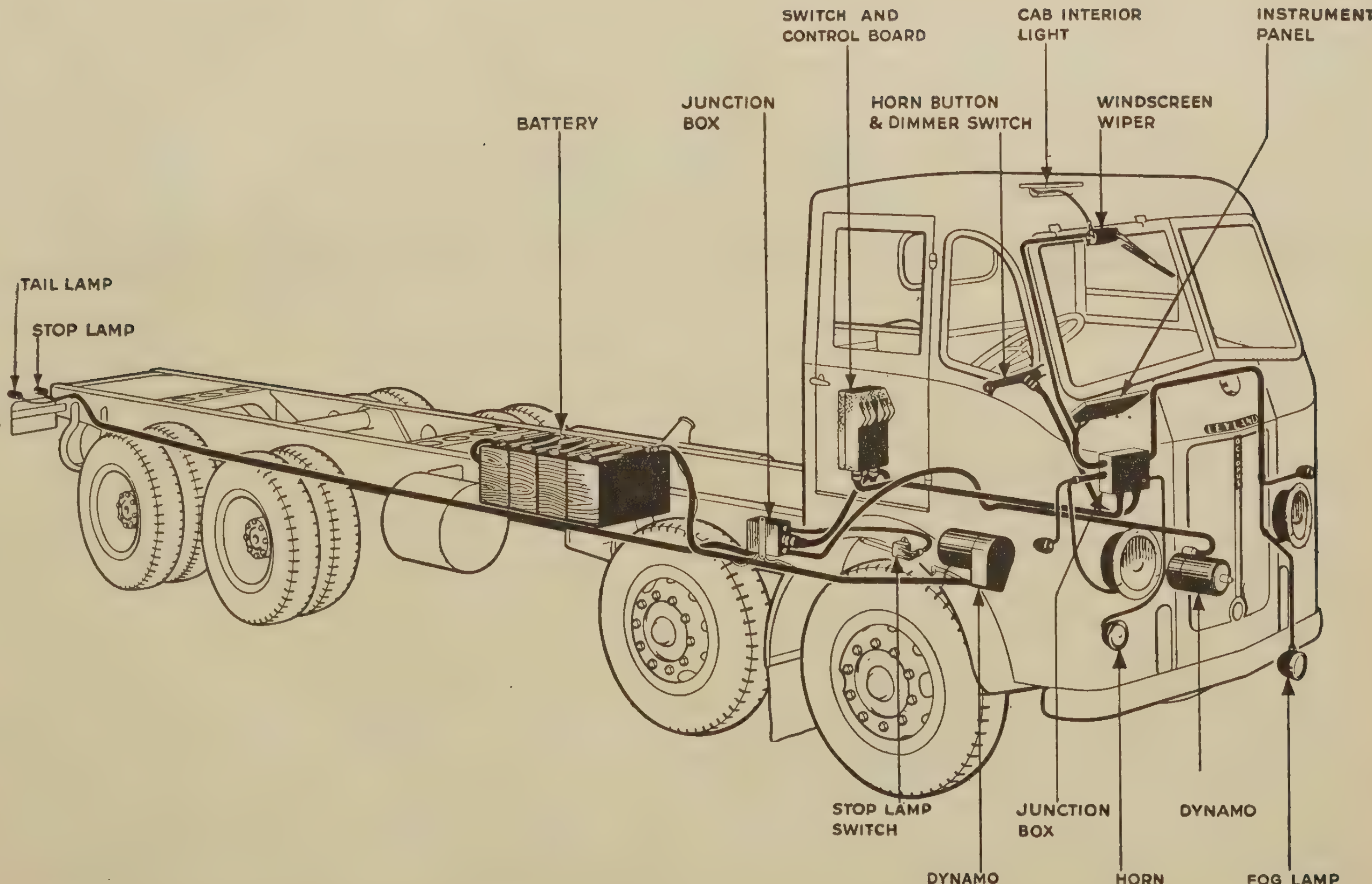


Fig. 197.—Showing the Layout of the Electrical Equipment in the Case of Leyland Commercial Vehicles.

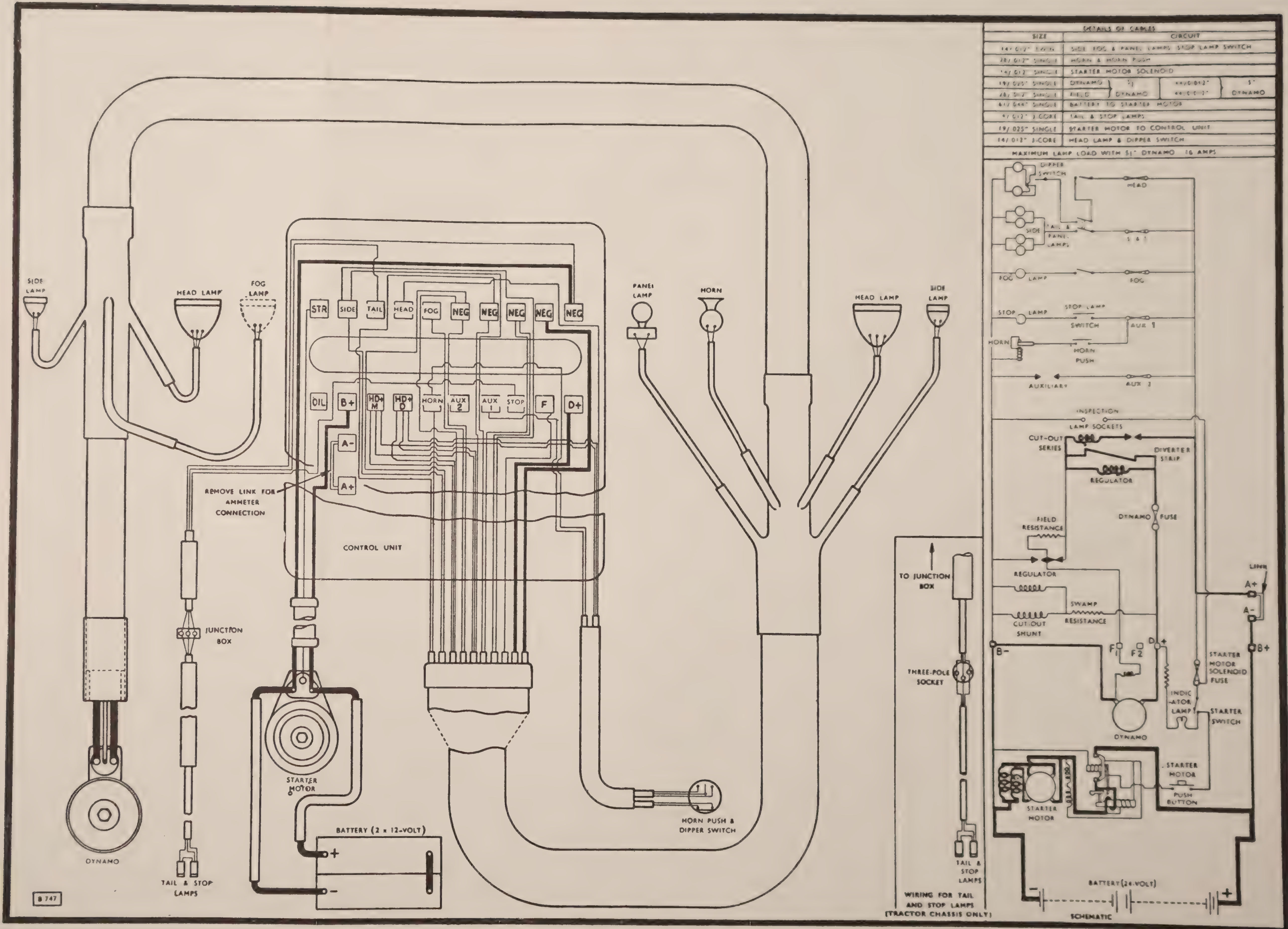


Fig. 196.—Wiring and Harness Diagrams (left) and Circuit Diagram (right) of the A.E.C. " Mammoth Major " Mark III Chassis.

(1) **The Straight 12-volt System.**—This is the conventional 12-volt wiring system with 12-volt lighting and starting. It is common to goods or passenger vehicles using petrol engines, and in some cases oil engines.

(2) **The Straight 24-volt System.**—This system is as the 12-volt system, but with 24-volt lighting and starting. It is used with oil engines where 24 volts are required for starting purposes, and in some petrol-engined buses with heavy lighting loads.

(3) **The Series Parallel System.**—With this system a 12-volt dynamo and 24-volt starter are used, and the batteries are connected in parallel for charging and in series for starting; change-over is effected by means of a series-parallel switch. This gives 12-volt lighting and 24-volt starting.

(4) **The Three-wire System.**—This is a balanced system (using a 24-volt dynamo and starter) whereby the batteries are connected in series and a neutral line is taken from the centre of the 24-volt unit, in which case from neutral to positive is an independent 12-volt circuit and from neutral to negative is another independent 12-volt circuit. The load is balanced from the two batteries, which is an obvious advantage. For example, the head-, tail-, and one sidelamp and half the interior lamps of the omnibus would be taken across neutral to negative side, and the fog-lamp, one sidelamp, windscreen wiper, horn, etc., and the other half of the interior lamps would be across the positive to neutral side of the circuit. When heater plugs are used, to avoid exhausting one 2-volt cell, the starter is connected across the 22-volt positive and the heater plugs across the remaining 2-volt cell. This system is used with large oil-engined vehicles and care must be taken to balance the load on both circuits.

Typical Vehicle Electrical Layout

The various electrical components, their locations on the vehicle, and the wiring layout of a typical Leyland heavy commercial vehicle, namely the "Beaver," "Hippo," "Octopus," and "Steer" heavy goods range of 1946 onwards, is shown in Fig. 197. These vehicles mostly use the C.A.V. instrument panels, Simms starter motor and dynamos.

Referring to Fig. 197, the cables are enclosed in harnesses. The 24-volt dynamo and battery system are employed. The dynamo has a maximum output of 240 watts at 940 r.p.m. The cutting-in speed is 780 r.p.m. (dynamo speed).

The starting motor is a 24-volt one with a gear reduction ratio of $13\frac{1}{4} : 1$ and is of the four-pole series-wound type. The electrical system employs both a junction box and a switch and control board.

Control Boards for Commercial Vehicles

It is now usual to provide commercial vehicles with control boards consisting of complete units for use in conjunction with dynamos and

operating, according to type, either on the compensated voltage-control or the current voltage-control system.

In addition to housing the regulator and cut-out, fuses are provided in the control board, together with terminals for cable connections and junction points. Regulator and cut-out, together with their attending resistances, are under a dustproof cover which is sealed after final adjust-

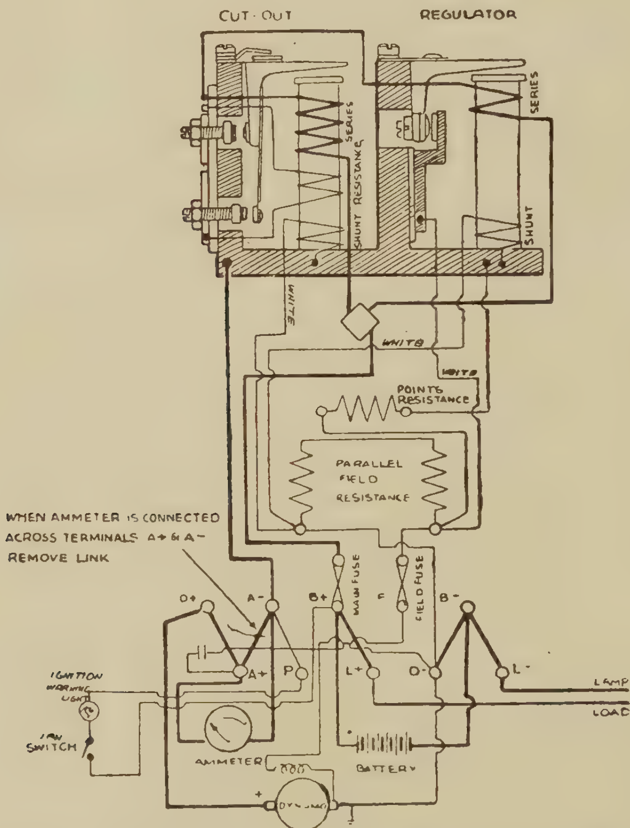


Fig. 198.—The C.A.V. Type 107C Wiring Diagram for Control Board.

ments and tests have been made. A separate easily removable cover permits access to the fuses and terminals when required.

These control boards are made in various types and the manufacturers supply tabular data regarding each specific type.

The wiring diagrams of two typical C.A.V. control boards, namely the Types 107C and 155, are shown in Figs. 198 and 199, respectively. The Type 107C control board has a compensated voltage-control system and uses a combined BK-type regulator and cut-out unit.

The Type 155 control board employs current voltage control with type C regulator and BCK cut-out units.

Maintenance.—Providing the control boards are mounted in a position where they are *not* directly exposed to oil and water and all terminal con-

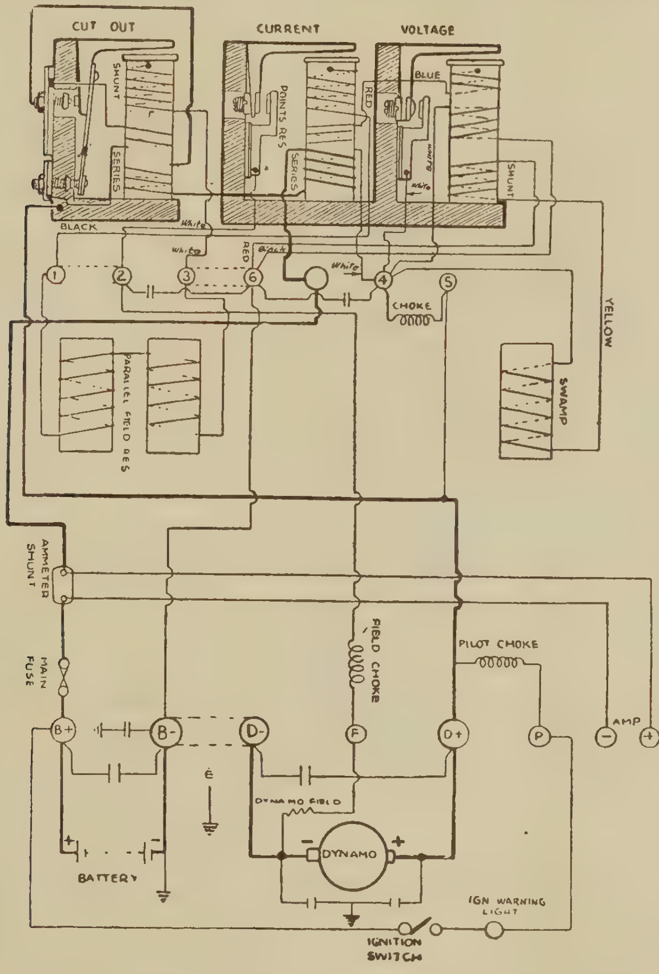


Fig. 199.—The C.A.V. Type 155 Wiring Diagram for Current Voltage control System.

nections are kept perfectly tight and clean, maintenance is almost negligible. Dependent upon working conditions, however, it becomes necessary at times to adjust and clean the regulator and cut-out as well as to replace the fuse.

As the working of complete low-voltage equipment is maintained entirely by the regulator and cut-out, no attempt whatever should be made

to adjust or replace parts unless adequate tools and facilities, as well as the services of a trained operator, are available. When these do not exist the complete control board should be returned to a C.A.V. Service Depot.

The control-board cover enclosing regulator and cut-out is sealed after final test and should on no account be interfered with unless there are reasonable grounds for suspecting the functioning of either regulator or cut-out.

The A.E.C. Electrical System

The arrangement of the wiring and the corresponding schematic electrical diagram for one of the A.E.C. " Mammoth Major " chassis, namely the Mark III, goods vehicles has been given in Fig. 196. It is now proposed to consider the practical aspects of this typical heavy-vehicle system. These vehicles are equipped with lighting, starting, and auxiliary units of either C.A.V. or Simms manufacture. The wiring system is of the two-wire insulated type, with cable harness clipped to the vehicle; this permits easy removal. The cables are enclosed in non-perishable synthetic rubber tubing, which is impervious to lubricating oil, fuel oil, and water.

The 24-volt dynamo, mounted on the engine, is driven by twin vee-belts from the crankshaft on the 9·6-litre engine and from the timing chain on the 7·7-litre one. It operates in conjunction with a regulator on the compensated voltage control system.

It employs a self-contained control unit which includes the switches, fuses, cut-out, dynamo regulator, etc., the control unit being located beside the driver.

It employs a 24-volt starting motor of the axial pattern. The equipment includes 24-volt head, side, tail and fog lamps, together with an instrument panel light, stop light, and switch. The panel light is controlled by the side-lamp switch on the control unit.

When an *engine oil-pressure indicator* is fitted, as in the case of certain other vehicles, a *green light* is included on the instrument panel, the lamp for which then serves as an instrument panel light and is illuminated as long as the oil pressure is satisfactory.

The battery is of the lead-acid type, consisting of two 12-volt batteries in series. The capacity of the battery is 102 or 113 ampere-hours at the ten-hour rate.

The Control Units (A.E.C. Vehicles).—Three alternative control units, one C.A.V. and two Simms, are fitted to the " Mammoth Major " and certain other vehicles. As space will not allow descriptions of all of these, one only, namely the Simms Type DQ (Fig. 200), will be described. It may, however, be mentioned that all of the control units have the following common features: (1) Battery main cut-off switch—except the Simms DQ unit; (2) compensated voltage-control regulator; (3) dynamo cut-out; (4) dynamo main fuse; (5) fuses for lamp and auxiliary circuits; and (6) sockets for a test ammeter plug.

Referring to the Simms DG control unit shown externally in Fig. 200, this is arranged alongside the driver, and it has at the top the warning light and the push button for the starting motor; this is secured to the cover by screws. There are four switches (Fig. 200), as follows: Headlamp, side and tail lamps, fog lamp, and starting circuit. Below the switches is a two-plug socket into which can be plugged an inspection-lamp flex connection. The screw shown at (1) (Fig. 201) is for securing the front cover. The latter, as will be seen from Fig. 201, carries all the units just mentioned, and has two hinges—seen on top—on the the back unit.

A view of this control box with the cover member open is given in Fig. 201, the various parts being indicated by the figure numbers and explained in the caption below. Of these the principal ones of present interest are the switches (41), starter push-button (13), dynamo warning light (49), the various circuit terminals (3) and (16), the set of fuses (4), cut-out (17B), and voltage regulator (17A). The moving contacts of the cut-out are shown at (7) and (8), whilst the vibrating contact of the regulator is shown at (5) and (6).

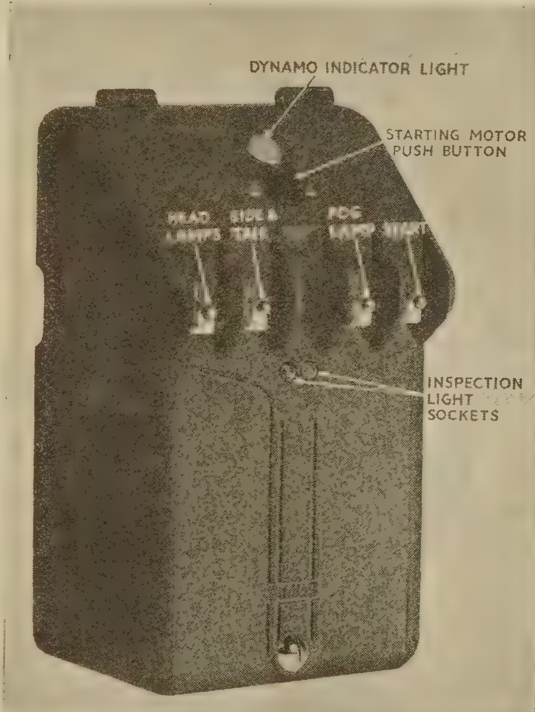


Fig. 200.—The Simms Type D.G. Control Box.

Here it may be noted that the *gap for the cut-out* should be set at ·060 in., and for *the regulator*, ·016 in. As the dynamo is speeded up, the contacts should close at 25 volts. As the dynamo speed is reduced, the contacts should open with a reverse current of less than 5 amperes. The cut-out must not be worked on until the battery has been disconnected.

Fuses.—These should be inspected at regular intervals to see that they are in their correct places, the contact faces are clean and bright, and the wire is of the correct size and has not deteriorated. In the event of a fuse blowing, after ascertaining and rectifying the cause new fuse wire should be fitted. *Spare fuse wire* is provided wound around the fuse bridge; in no circumstances should any other size, gauge, or material be used. The names of the components protected by the fuses are clearly shown on the fuse bridges. In regard to the *diverter strip* (10) (Fig. 201), this controls

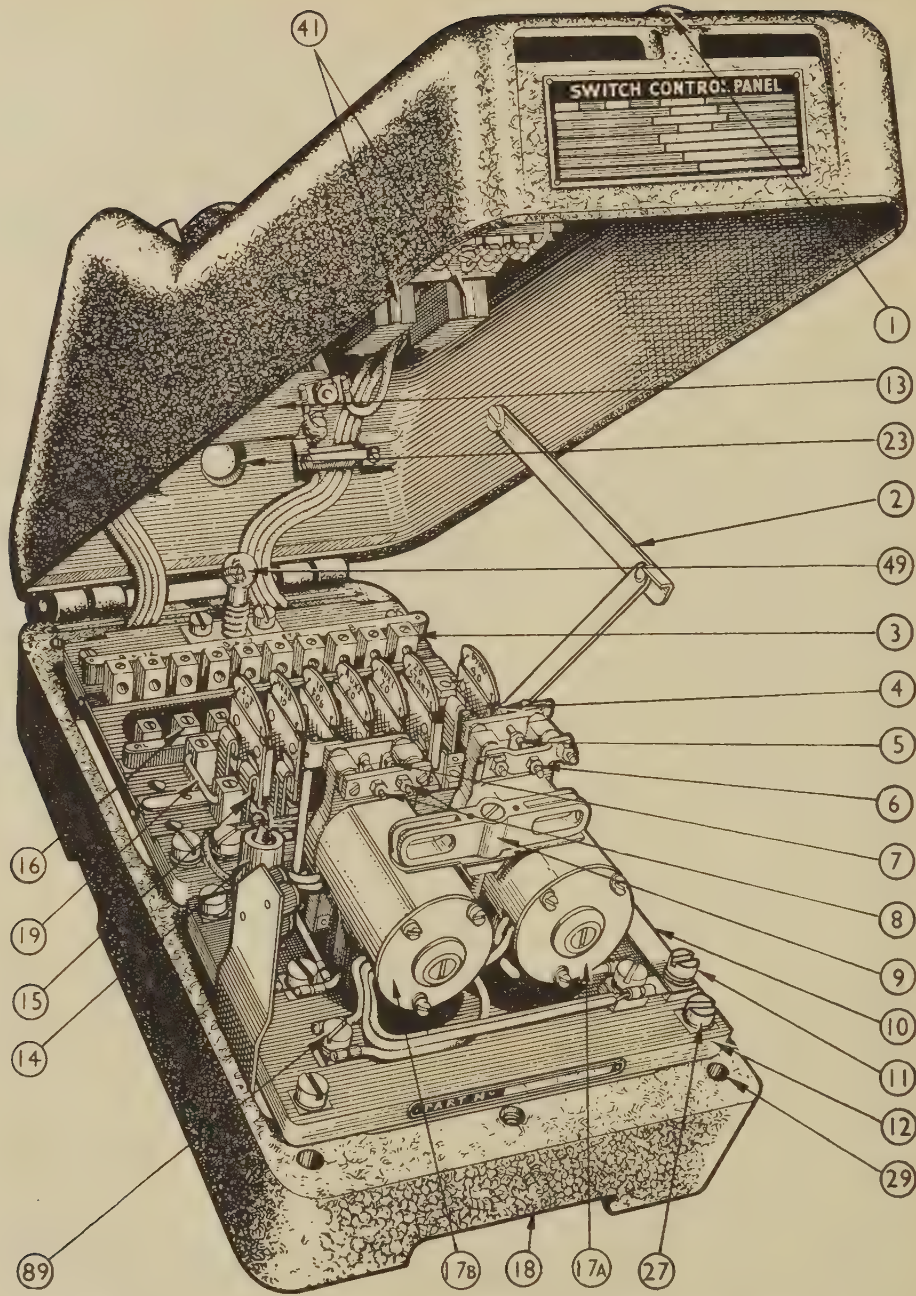


Fig. 201.—The Simms DQ Control Unit as used on A.E.C. and Leyland Vehicles.

1, Cover Securing Screw. 2, Cover Hinged Strut. 3, Cable Terminals 4 Set of Fuses. 5 and 6, Vibrating Contacts of Regulator. 7 and 8, Cut-out Contacts. 9, Securing Bridge. 10, Diverter Strip. 11, Securing Screw. 12, Base Plate. 13, Starter Push-button. 14, Stop-lamp Switch. 15, Fuse Clip. 16, Terminals. 17A, Voltage Regulator. 17B, Cut-out. 18, Base Unit. 19, Bridge. 23, Dynamo Warning Light Aperture. 27, Base Screws. 29, Holding Down Bolt Hole. 41, Switches. 49, Dynamo Warning Light, 89, Cut-out Connection Terminal.

the operation of the voltage regulator and therefore the characteristics of the dynamo.

In connection with the other electrical components of the A.E.C. vehicles, e.g. dynamo, cut-out, regulator, starting motor, and starting switch, these are mostly covered by the instructions given in the next chapter.

The following tabular information on fuse-wire sizes and lamp bulbs may be found useful to the service engineer:

SIZES OF FUSE WIRE (A.E.C.)
(in S.W.G.)

Control Unit	*Side and Tail Lamps*	*Headlamps*	*Fog Lamp*	*Auxiliary*	*Dynamo Main*	*Starter Motor Solenoid*	*Remarks*
C.A.V. 104A	34	34	34	34	Strip-50/amp	—	Only tinned copper wire to be used
Simms CP	30	30	30	30	28	—	
Simms FR	36	36	36	33	28	—	
Simms DQ	36	36	36	33	28	33	

HEADLAMP AND OTHER BULBS (A.E.C.)

Side, Tail, Stop, Panel and Oil-warning Bulbs	*Headlamp and Fog Lamp*	*Dynamo-charging Indicator Bulbs*	*Control Unit Type*
24-volt, 6-watt	24-volt, 36-watt	24-volt, 6-watt } Double contact (S.B.C.)	C.A.V. 104A
		16-volt, 8-watt } Double contact (S.B.C.)	Simms CP
Double-contact (S.B.C.)	Double-contact (S.B.C.)	16-volt, 8-watt } Single contact (M.E.S.)	Simms FR
		16-volt, 3-watt } Single contact (M.E.S.)	Simms DQ

CHAPTER 7

THE DYNAMO OR GENERATOR

THE object of the generator is to keep the battery fully charged at all times. It should commence charging the battery at a fairly low engine speed, namely that corresponding to a road speed, on top gear, of 10 to 12 miles an hour. When the battery is fully charged, the dynamo should cease to supply current to it, for any further charging merely results in heating and evaporating the battery acid.

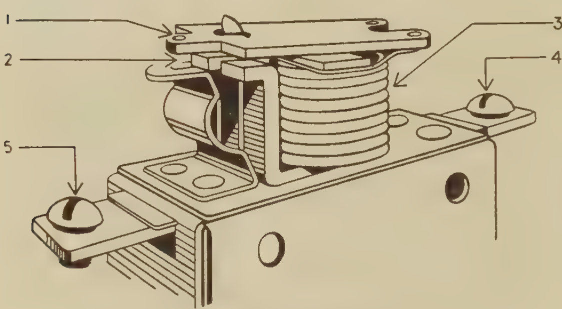


Fig. 202.—A Typical Automatic Cut-out.
1, Moving Armature Contact. 2, Fixed Contact. 3, Electro-magnet. 4 and 5, Cable Connection Screws.

All modern dynamos are fitted with an automatic device for connecting the dynamo output lead with the battery when a certain minimum speed of rotation (usually corresponding to about 12 to 16 miles an hour) is reached, and to disconnect it from the battery when the engine is stopped; this prevents the battery from discharging through dynamo windings.

Fig. 202 illustrates a popular type of automatic "*cut-out*" relay for this purpose. It consists of an electro-magnet, the windings of which form a part of the generator circuit.

The cut-out relay consists of a set of magnetically operated contacts that are held open by a tension spring and closed magnetically. When the engine is not running the contacts should be open. They are open also when the speed of the generator is too low to enable it to charge the battery. Around the core of the magnet is a double winding consisting of a voltage coil of a large number of turns of very fine wire, connected between the generator terminal and earth, and a current coil made up of a few turns of very heavy wire. The current coil is connected in the charging circuit in series with the contacts, and is energised only when the contacts are closed. The actual closing of

these contacts is caused by the magnetism created by the voltage coil, or fine winding, when the generator operates at sufficient speed to charge the battery.

How the Cut-out Operates

If the working operations of the ordinary automobile type of cut-out are clearly understood no difficulty should be experienced in dealing with its electrical troubles, adjustments, etc.

Fig. 203 shows the wiring circuit of the common form of automatic

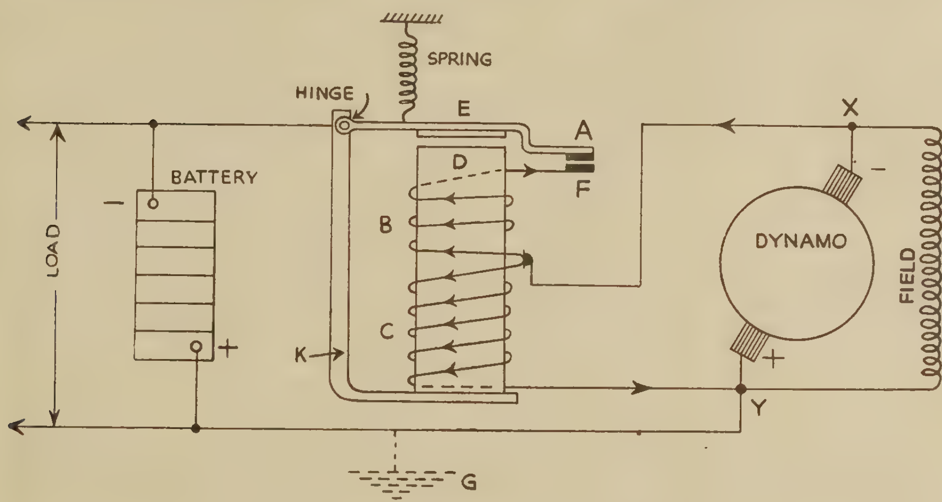


Fig. 203.—Illustrating the Principle of the Cut-out.

cut-out (known also as the reverse-current relay) used upon most motor vehicles.

The cut-out in question consists of a central soft-iron core D attached to an L-shaped member K, having at its upper end a hinge, to which an iron lever EA is hinged. Normally this lever is held upwards, against a stop by means of the spring shown.

The iron core D carries two windings, the upper one B of which is designed to carry the full dynamo current, whilst the lower one C is a voltage coil shunted across the positive and negative brushes X and Y, respectively, of the dynamo.

Fig. 204 shows the two windings of the cut-out in their simplest form, from which it will be seen that the fine-wire winding is connected in shunt, or parallel, and the thick one in series. The three cut-out connections in the charging circuit are as follows: A input from dynamo to shunt winding, B return to opposite polarity conductor; C to battery

negative terminal. In modern electrical systems the conductor B is earthed to the chassis frame.

Referring to Fig. 203, it will be observed that the members D, E, and K form a complete magnetic circuit when the contacts A and F are closed.

When the dynamo is running at a low speed the current flowing through the shunt voltage coil C is insufficient to magnetise the core, but when the speed increases to a certain value (corresponding to about 12 or 16 miles per hour on top gear) the core is magnetised sufficiently to attract the armature lever E, and thus close the contacts A and F. The main current from the dynamo then flows to the battery, and the ammeter gives a "charge" reading. The contacts A and F are held together all the time the dynamo speed is greater than that corresponding to the manufacturer's *specified cutting-in speed*, e.g. 700 to 1,000 r.p.m. of the dynamo, according to the type.

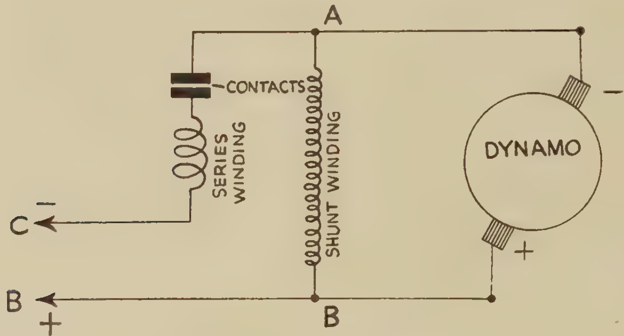


Fig. 204.—The Cut-out Windings.

Cutting-in Voltages

The cut-out, if in correct condition and adjustment, should come into operation as the dynamo speeds up from rest when its voltage just exceeds that of the battery. The following are typical cutting-in voltages:

Battery Voltage	*Cut-out Voltage*
6	6·5–7·0
12	13–14
24	25–27

With this knowledge it is not a difficult matter to test the cutting-in voltage and speed, using a moving-coil voltmeter connected across the main plus and minus dynamo terminals. The speed can be tested with a revolution counter or tachometer.

Adjustment and Care of Cut-out Relays

The "cut-out" being automatic in action requires no lubrication, and but little attention beyond seeing that the wires leading to it have tight connections.

The "cut-out" seldom gives trouble, but if any dirt gets between the

contacts it may fail to operate, and will then prevent the generator charging the battery until a fairly high speed is reached.

The possible faults with cut-out units that should be looked for in the event of any trouble arising are as follows:

(1) Dirty contacts.
(2) Contact gap incorrect.
(3) Armature sticking in bearings.
(4) Short circuit or break in voltage or current winding.
(5) Dirty terminal connections.

The contact gap should be set to the value recommended by the equipment manufacturers. This value usually lies between ·012 and ·016 in., and it is generally set to the given value by bending the strip carrying the movable contact.

The voltage method of checking, as described later, should be employed for final adjustment.

Double Contacts.—In many commercial-vehicle cut-outs two pairs of contacts are fitted, owing to the large current to be dealt with. The auxiliary contacts are arranged to close first, so as to take care of any sparking, whilst the main contacts close later and are unaffected.

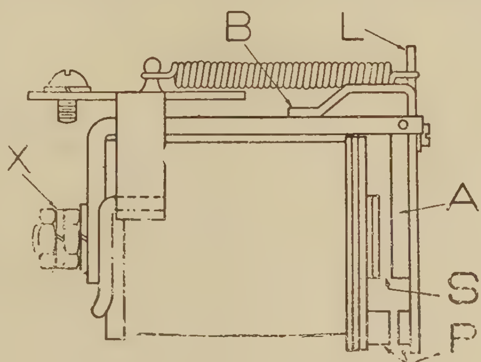


Fig. 205.—Illustrating Adjustment of Cut-out Relay.

Typical Cut-out Adjustment.—The maintenance and adjustment of a motor-car cut-out will now be considered.

Referring to Fig. 205, the air gap S between the armature A and the end of the cores should be ·025 in. to ·035 in. when the contacts are closed.

The gap between the contacts P in this particular design should be ·025 in. to ·035 in. Secure the adjustment by bending with a pair of pliers the brass stop B. This is important, as the amount of air gap largely determines the " cut-in " point. Contacts should meet squarely, and the brass blade carrying the moving contact should be straight and parallel to the surface of the armature A. To clean the contacts or square them up, a strip of fine sandpaper should be drawn between the contacts while they are lightly closed by hand. The end of the blade carrying the moving contact may be prevented from rubbing inside the relay cover by grinding or filing off the end of the blade to a point $\frac{1}{64}$ in. from the side of the contact.

In checking the voltage at which the relay points close, use a voltmeter capable of indicating at least 10 to 15 volts. Connect one of the voltmeter leads to the terminal X and the other lead to the relay base or generator frame. If the needle of the voltmeter deflects in the wrong direction, reverse the voltmeter lead connections.

Slowly speed up the engine and observe the voltmeter reading. The contacts should close at 7 to 8 volts on this relay. Any necessary adjustments should be made by bending the lug L slightly. Increasing the spring tension will raise the " cut-in " voltage; decreasing the tension lowers it.

The contacts should open with the discharge from the battery through the relay with rather less than 3 amperes in this design. As soon as the contacts close, the ammeter on the dash should indicate that the generator is beginning to charge the battery.

Commercial-vehicle Cut-outs.—The cut-out units employed on most commercial heavy vehicles are of more robust construction, and although operating upon the same principle as previously explained differ in design and certain other details. A typical example is the Simms Type L cut-out used on certain A.E.C. and Leyland vehicles, shown externally in Fig. 206. The shunt coil is wound over a soft-iron core, with the thicker wire series coil wound on top of it. Both are enclosed in a metal barrel for protection purposes. The contacts have a working gap of ·060 in., and normal and fine adjustments are provided for the gap and control spring respectively.

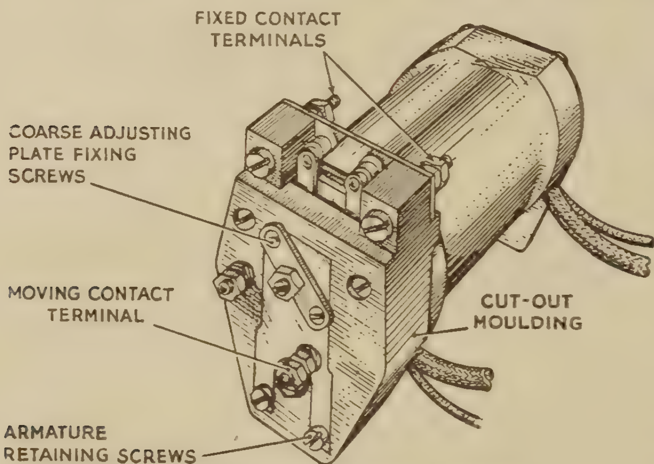


Fig. 206.—The Simms Type " L " Cut-out.

Adjustment of Cut-out.—It should be noted that there are two pairs of contacts in parallel, the moving ones being mounted in a flexible U-piece attached to the armature. The fixed contacts are mounted in a cross-bar and locked by nuts.

To adjust, first disconnect one lead from the battery and proceed as follows:

(1) The contact gap is slackened off the fixed contact nut, and then the contact is screwed in or out to give the correct gap of ·060 in. After locking the fixed contact lock-nut, check the gap again.

(2) Remove the two fixing screws from the adjusting plate which is mounted in the centre of the top end of the cut-out. Run the dynamo so that it is generating 24·5 volts. The adjusting plate should then be rotated, holding the centre vernier screw stationary with a screw-driver until the contacts close. Replace the adjusting plate fixing screws, and finally adjust the setting with the centre vernier screw and check the setting. Finally check the reverse current as the dynamo slows down.

The value of this current when the contacts open should be 3 to 4 amperes.

If satisfactory results are not obtained after these adjustments either the cut-out unit is defective—when a new one should be fitted—or the voltage regulator is not operating correctly, and should therefore be tested.

Testing the Cut-out.—As an example of the method of testing a cut-out that shown in Fig. 207 will be considered. Before testing, disconnect one of the battery leads to ensure that no short-circuiting will occur during the stationary dynamo test. Then:

(1) With the contacts fully open the gap should be ·060 in., as previously mentioned. When the contacts meet again the gap between the armature and the barrel should be ·022 in., as indicated in Fig. 207.

(2) Connect a moving-coil voltmeter with a range of 0 to 30 volts to the plus and minus terminals of the dynamo. Then run the latter and note the voltage at which the contacts close. This should be 24·5 volts for the 24-volt battery system.

(3) Next re-connect the battery and run the dynamo until a charge of 2 to 3 amperes is obtained. Then slow the dynamo down and note the value of the reverse current that causes the cut-out contacts to open; this should be 3 to 4 amperes.

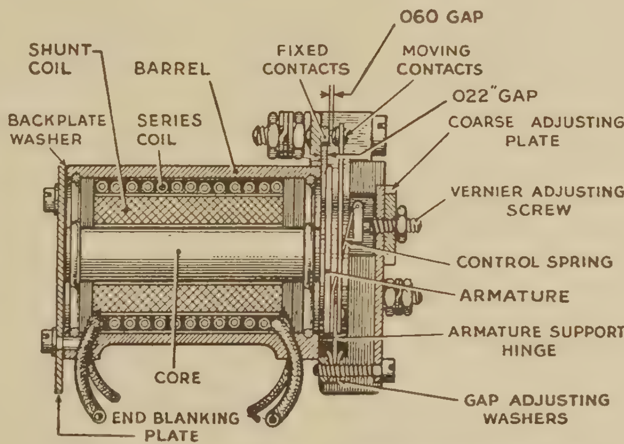


Fig. 207.—The Simms Type " L " Cut-out in Sectional View.

(4) Inspect the contacts, and if found to be burnt or pitted they should be cleaned gently with fine carborundum paper. If worn appreciably new contact units should be fitted.

Combined Cut-out and Regulator

Instead of having a separate cut-out arranged on or near the dynamo, as on earlier vehicles having third-brush voltage regulation, it is now the usual practice to combine the cut-out, regulator, auxiliary circuit terminals, and fuses in one unit, known also as the *control box*. A typical example of such a unit is the Lucas R.F.91 shown in Fig. 189 on page 187. The cut-out and regulator solenoids are of similar size and shape, and are housed under a removable cover. The adjustment and maintenance of the cut-out is the same as described earlier for the separate unit. The adjustment of the regulator unit is dealt with later in this chapter.

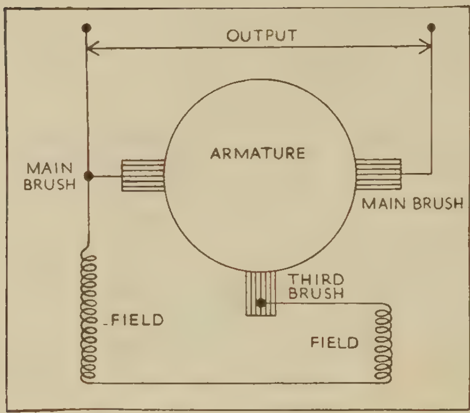


Fig 208.—The Three-brush Dynamo.

Third-brush Regulation

Although numerous method have been used for maintaining the voltage of the dynamo constant over a wide range of engine speeds, the most popular method in its day was that known as the *third-brush* regulation.

In this case, in addition to the two main brushes from which the output is taken, there is a third brush mounted in an intermediate position between the other two (Fig. 208). This brush is connected to one end of the field-magnet energising coils, the other end of these coil windings being connected to one of the main brushes.

The result of this arrangement is to give a smaller field excitation, the current through the field resistance being proportional to the E.M.F. at the extremities of the winding. In this way, by suitably locating the third brush and careful proportioning of the field windings the voltage increase at high speeds can be compensated for, automatically, by the decreased magnetisation of the field magnets.

It is important, however, to remember that as the battery forms part of the electrical system—being one of the resistances in the armature circuit—*it is necessary always to have the battery in the circuit.* If this is removed the system is no longer a

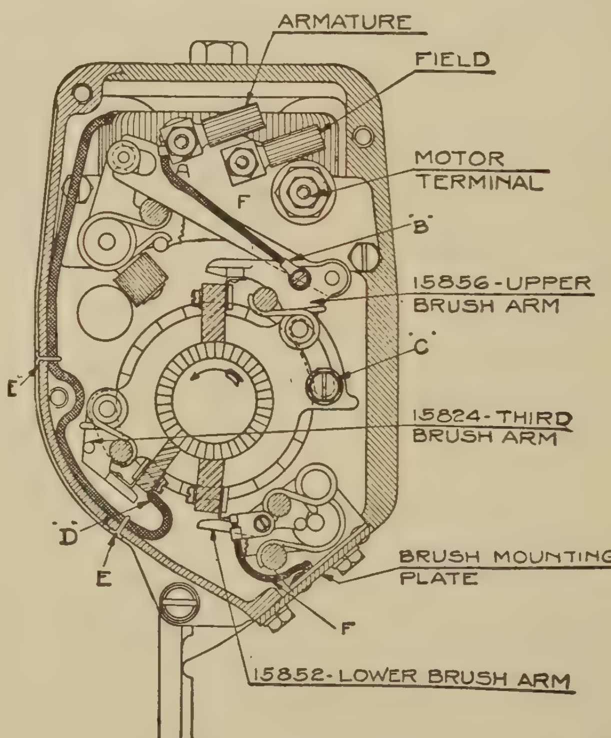


Fig. 209.—One Model of Dynamo, showing the Three Brushes and other Important Components.

constant-voltage one, so that the voltage will increase to such an extent that the lamps will burn out.

Complete Charging Circuit.—The complete charging circuit of the Fordson vehicle fitted with three-brush dynamo is shown in Fig. 210. This diagram also shows the cut-out, ammeter, and battery. It will be observed that one dynamo brush is earthed, as is one end of the cut-out voltage coil and the positive battery terminal.

Delco-Remy Three-brush Dynamo.—Fig. 209 shows the earlier model Delco-Remy three-brush generator.

Referring to Fig. 209, before the position of the third brush is changed in an attempt to obtain a higher charging rate, be sure to have the commutator surface inspected for excess oil or grease or other abnormal conditions, which, if corrected, would automatically raise the charging rate to the proper value without any actual change in third-brush position. All wiring and storage battery connections in the charging circuit should be checked up for open circuits, and loose or corroded connections.

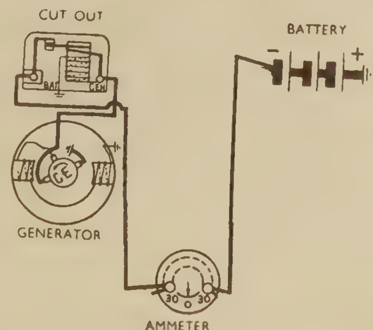


Fig. 210.—The Fordson Three-brush Dynamo.

At a road speed of about 20 miles an hour, with no lights on, the Delco-Remy type of generator gives a charging current of 10 to 15 amperes. When the car is run at a lower speed the output is proportionately less. At *higher car speeds the charging rate is actually less* than at about 20 miles an hour, due to the third-brush regulation method.

When adjusting the charging rate an ammeter should be connected in the charging circuit and should be observed while the engine is gradually speeded up, and the maximum rate noted. With the lights off, the reading of the ammeter on the dash should not exceed 15 amperes when the generator is hot. If an ammeter were connected in the circuit at the generator terminal the reading, with the lights off, would be 16–18 amperes, which is the gross charging rate and includes the current used for ignition.

The third-brush arm should be tightly clamped after adjustment. Different types of third-brush generators each have their own particular methods of adjustment and clamping means; a careful inspection will show the correct method in each case.

Fig. 211 illustrates a car dynamo from the commutator end. The dynamo in question is a simple self-regulating third-brush machine, arranged to give its full, or a reduced, output according to the position of the charging switch.

The commutator brushes are readily accessible when the cover is removed. Its surface must be kept clean and free from any oil or brush dust.

The instructions previously given for the care and maintenance of other commutators apply also in this case.

To fit a new brush it is only necessary to release the brush tag, hold back the trigger, and then withdraw the worn brush from its holder. The new brush can be fitted by reversing the above operations.

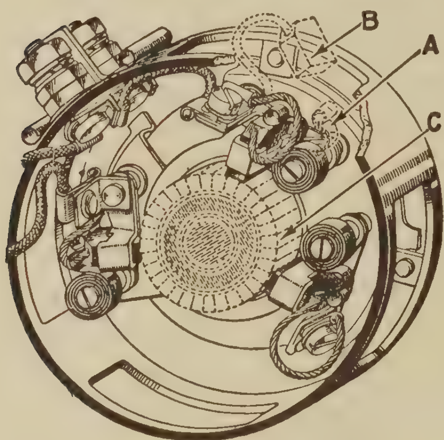


Fig. 211.—A Typical Three-brush Dynamo Commutator.

A, Brush Spring Clip.
B, Brush.
C, Face of Commutator.

Three-brush Dynamo with Resistance Regulator.—A popular type of dynamo, developed by Messrs. Lucas, Ltd., and fitted to a large number of cars, was the three-brush model having three different charging rates. Thus under constant winter day and night driving conditions the full charging rate was obtained by means of the switch (Fig. 212) moved over to position (1). For summer daytime driving an appreciably lower rate is necessary to prevent constant overcharging of the battery. This is achieved by inserting two resistances R_1 and R_2 in the circuit, by moving the switch to position (3). In this case the charging rate was reduced to about one-third of the full value. For most normal driving purposes the switch was moved over to position (2), in which the single resistance R_1

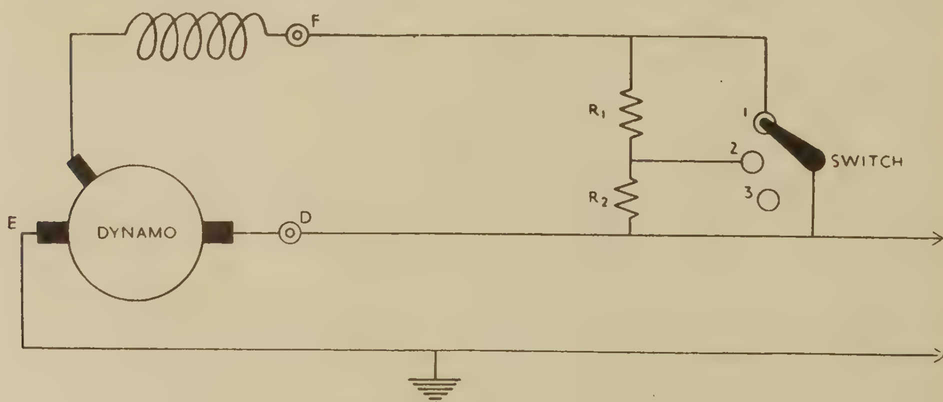


Fig. 212.—Three-brush Dynamo with Resistance Regulator.

was inserted to give a charging rate of about two-thirds the maximum rate. The switch of the Lucas system was combined with the lighting one. The field circuit of the dynamo, remote from the brush, was taken to a terminal marked " F." The other dynamo terminal " D " was connected

to the opposite polarity circuit to that earthed; thus if the earthed terminal " E " is negative the one shown at " D " would be positive.

Disadvantages of Three-brush Dynamos.—Whilst giving satisfactory service on earlier cars, the three-brush dynamo characteristics or performance depended upon the state of the battery and the engine speed. Thus the charging current rises rapidly at moderate speeds and falls off as the speed is increased above these values. Moreover, the charging rate tends to be low when the battery is low and to increase as the battery becomes fully charged. It was for this reason that the three-rate Lucas charging system was introduced.

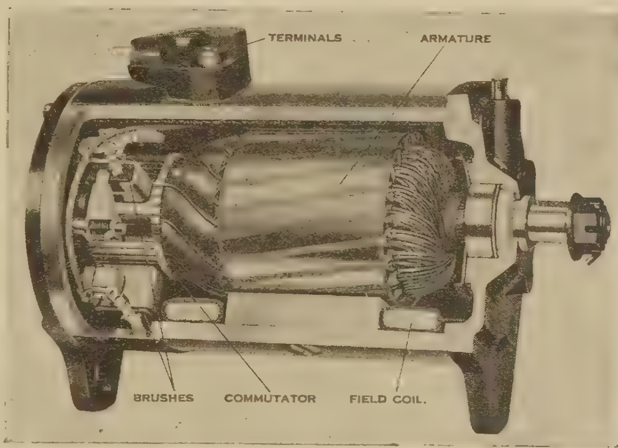


Fig. 213.—Typical Lucas Generator in Part-sectional View.

Again, the output of the three-brush dynamo is not sufficient to supply the greatly increased electrical demands of modern cars and other vehicles, unless its size and weight are appreciably increased. The introduction of the automatic voltage and current regulating dynamo systems has overcome the drawbacks of the three-brush type, so that the latter is only to be found on earlier cars still in service.

Thermostat Method of Current Control

There is another method, namely, the *thermostat* one, of controlling the generator output with or in addition to the third-brush method of regulation. This device (Fig. 214) operates in case of an excessive charging rate to protect the generator from overheating and the battery from overcharging. The thermostat is usually mounted on the third-brush arm, in a position readily influenced by radiated heat from the generator. It consists essentially of a coil of resistance wire and a set of contacts.

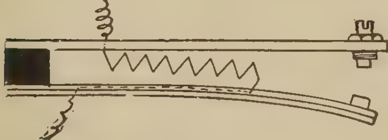


Fig. 214.—The Delco-Remy Automatic Battery Shunt Device.

The blade holding one of the contact points is made from a piece of bimetal consisting of a strip of brass welded to a strip of nickel steel. This combination warps at its free end when heated, due to the greater expansion of the brass side. The contacts, normally closed, are caused to separate at

at a temperature of 195° to 205° F. within the generator. Thus the field current, which previously passed through the contacts, is shunted through a resistance. The direct field current is restored as soon as the temperature has again become normal. No attention is required by the thermostat, and its operation, which is accompanied by a sudden drop of 45 to 50 per cent. in the ammeter reading, should cause no concern.

Compensated Voltage-control Dynamos

The earlier three- and four-brush dynamos have more recently been replaced to a considerable extent by another type having only two brushes, designed for automatic regulation of the dynamo output *to suit the condition of the battery*; the two-brush dynamo is employed in most British and in certain American cars.

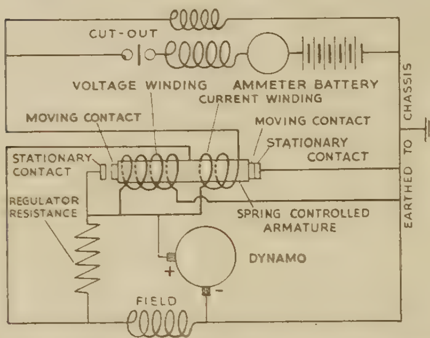


Fig. 215.—Typical Lucas Two-brush Dynamo System.

The system comprises a special type of dynamo and a regulator unit; it should be noted that although similar in appearance to the three-brush machine, the dynamo is wound differently and has only two brushes.

The regulator unit is usually mounted on the dash and is integral with the cut-out, fuse, and junction box.

The principle upon which the dynamo system (Fig. 215) works is as follows:

The regulator causes the dynamo to give an output which varies according to the load on the battery and its state of charge. When the battery is discharged the dynamo gives a high output, so that the battery receives a quick recharge which brings it back to its normal state in the minimum possible time. On the other hand, if the battery is fully charged, the dynamo is arranged to give only a trickle charge which is sufficient to keep it in good condition without any possibility of causing damage to the battery by overcharging.

In addition to controlling the output of the dynamo according to the condition of the battery, the regulator provides for an increase of output to balance the current taken by the lamps or other accessories whenever they are switched on.

It is important to remember that, in general, *a low reading of the ammeter indicates a practically fully charged battery—not a faulty dynamo.*

The advantages of this system include longer battery life, owing to more efficient charging; prevention of overcharging and the need for "topping up" the battery acid at frequent intervals; safer night-driving on account of the steady voltage and higher battery-charge state, and the

dispensing with the usual dynamo-charging switch and the "Winter" and "Summer" charge positions, necessitating the attention of the driver.

How the System Operates

The operation of the regulator, as previously mentioned, depends upon the fact that the voltage of a battery varies between certain fixed limits according to the state of charge, the voltage being a maximum when the battery is fully charged and a minimum on its discharge.

The windings consist of a voltage winding connected directly across the dynamo terminals and a current winding which carries the full current from the dynamo to the battery. These coils assist each other in energising the magnet system and thus in effecting movement of the armature.

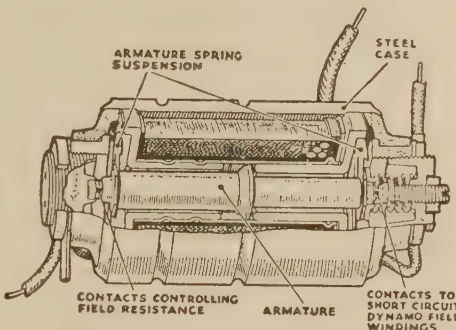


Fig. 216.—The L.R. type of Regulator Unit.

When the dynamo voltage reaches a predetermined figure, the magnetic field due to the voltage winding becomes sufficiently strong to attract the armature. This causes the first set of contacts to open, thereby inserting the resistance in the field circuit. This reduction on field current lowers the dynamo voltage, and this, in turn, weakens the magnetic field due to the voltage coil. This allows the armature to return to its original position, thus closing the contacts, so that the voltage returns to the predetermined maximum. The cycle is then repeated, and the armature is set into vibration.

As the speed of the dynamo rises above that at which the regulator comes into operation—about 20 m.p.h.—the amplitude of vibration increases and the periods of interruption increase in length, with the result that the mean value of the voltage on the machine terminals undergoes practically no increase once the operating speed has been attained.

The series winding provides a compensation on this system of control, for if the control were arranged entirely on the basis of dynamo voltage there would be a risk of very seriously overloading the dynamo when the battery was in a low state of charge, particularly if the lamps were simultaneously in use. Under these conditions the dynamo would be forced to give an output to bring the voltage of the system up to the same value as if the battery were in its normal fully charged condition, and this, with a battery of low internal resistance, would necessitate an extremely heavy current far beyond the normal capacity of the machine. The series winding assists the voltage coil, so that when the dynamo is delivering a heavy current into a discharged battery the regulator comes into operation at a somewhat reduced voltage, thus limiting the dynamo output accordingly.

Typical Constant-voltage System

The schematic diagram given in Fig. 215 enables the theory of the constant-voltage system to be understood, but it does not give any accurate idea of the wiring layout of a typical unit.

For this reason we have included a diagram showing the complete charging system as illustrated in the case of the Fordson vehicles (Fig. 217). Here the dynamo "CE" is of the usual two-brush pattern, with one brush earthed and the negative output terminal led to the "D" terminal of the *control unit*, which contains the cut-out (on right) and voltage regulator (on left) as well as the terminals for cables leading to the principal electrical units.

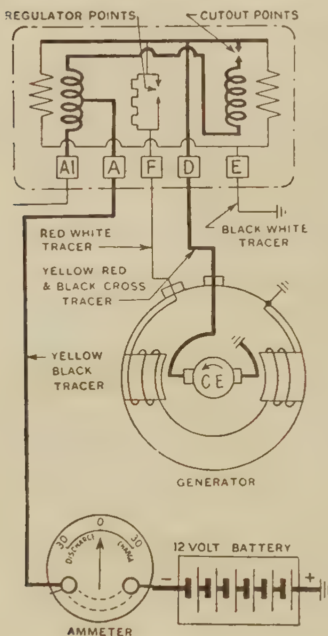


Fig. 217.—The Fordson Constant-voltage Control System Wiring Diagram.

When the dynamo is running above the cutting-in speed, the output passes through the cut-out and regulator units to the output terminal "A," from which it passes along the yellow-black tracer cable to the negative terminal of the ammeter; this is graduated from -30 to 0 to $+30$ amperes. From the positive terminal of the ammeter the charging current goes to the negative terminal of the 12-volt battery; the positive pole of this is earthed to complete the battery to dynamo circuit.

In regard to the *field windings* of the dynamo, one end is earthed, as shown on the right in Fig. 217, and the other end is taken to the "F" terminal of the control box.

Maintenance of the Dynamo.—In general the dynamo system requires very little attention in service, although in certain special circumstances it may be necessary to alter the charging rate; the manner of doing this is described later.

Regulating the Automatic Voltage-control Dynamo Output

The Lucas regulator units as first issued were known as the L.R.1 and L.R.2 types; later patterns of a somewhat improved design were the L.R.3 and L.R.5 types.

Referring, first, to the two former-model regulators, although the factory setting of these is entirely satisfactory, the dynamo output for certain special purposes is sometimes considered too low. This is often the case when the car owner is a doctor or traveller making frequent stops and starts without long runs sufficient for making up for the drain on the battery.

Continuous night-driving and cold-weather starting are other occasions when a higher charging rate is desirable. Further, in some cases, probably with a view to saving wear of the dynamo commutator and brushes, the setting has been rather on the low side; and since there does not appear to be any practical information easily available for those who cannot in such cases send the car to a Lucas Service Station, and so must make the adjustments themselves, the method will, perhaps, be found useful.

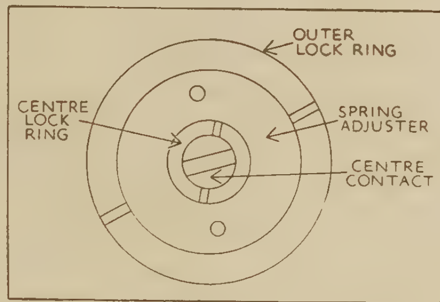


Fig. 218.—L.R. Regulator Adjustment.

The adjustments to be made, when understood, are simple enough, but care must be taken to follow out the routine given exactly, the only special appliance really essential being an accurate and sensitive voltmeter, together with a few simple tools.

Before commencing the adjustments break the seal on the cut-out and regulator cover and remove same, and notice the type markings. If these are L.R.1 the tests may be made with the regulator in position, but if marked L.R.2 the regulator must be removed from its base, to enable the adjustment to be easily made.

Assuming type L.R.1 is to be adjusted, note the type of switch and fuse block on which it is mounted; if marked "R.J.F." remove the *main fuse*, if marked "R.F." disconnect the lead attached to terminal A and remove the *auxiliary fuse* before making the adjustments; *don't disconnect the regulator leads.*

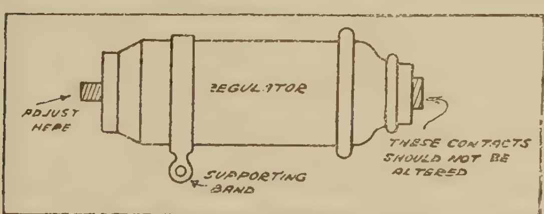


Fig. 219.—L.R. Regulator Adjustment.

Now connect one lead from the voltmeter to the dynamo positive terminal and the other to the chassis, making a good "earth," and start the engine. Open up the engine very slowly and watch the voltmeter needle, not the voltage at which it "kicks" and then becomes steady. This should read not less than 15 volts; if lower, stop the engine and proceed as follows:

Release the outer locking ring on the regulator adjustment (Fig. 218) and turn the spring-tensioning adjuster in a *clockwise* direction a little and relock; next unlock the centre adjustment and turn it the same amount in an *anti-clockwise* direction and relock. A very small movement only is needed; about one-quarter turn gives one-volt variation, increase or decrease.

Now start up again and check the "kicking" point again. If this occurs at about 15·5 volts it will be found best to leave it at that; if the engine is

speeded up a second " kick " should take place at about ·5 volt higher, or thereabouts, but in no case should it be at a higher reading than 16·5 volts; if it does the regulator must be set back a little.

When the regulator is type L.R.2 it must be held in a horizontal position by positioning straps attached to it and the regulator-fixing screws when making the adjustments, or otherwise it must be refitted to the base each time before starting up.

Suitable tools for loosening the locking rings and also special positioning straps may be obtained upon application from the makers, Messrs. Joseph Lucas, Ltd., or from any of their Service depots.

The L.R.3 and L.R.5 Models.—With reference to these later models, in each case they are incorporated with the cut-out assembly, which they closely resemble, the contact points being visible and easily cleaned (Fig. 220).

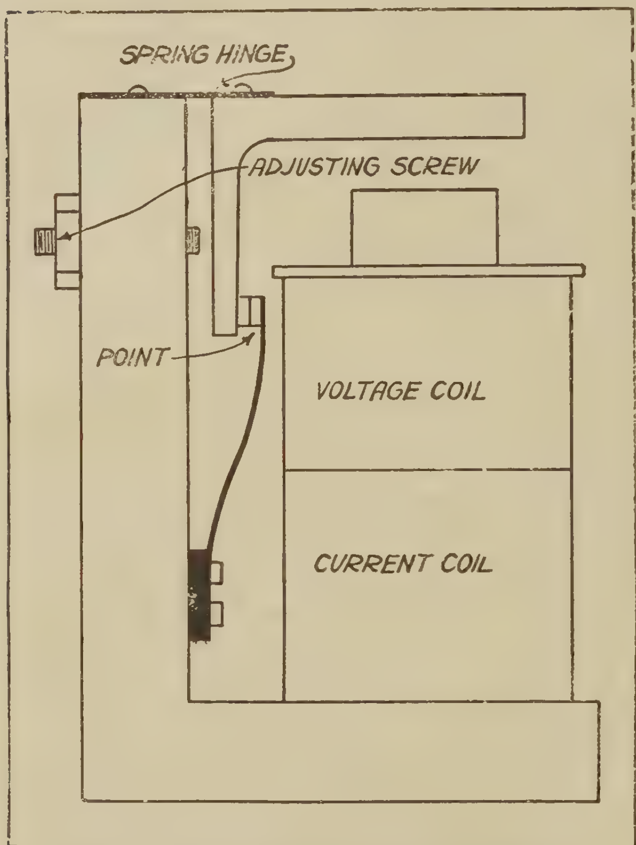


Fig. 220.—The L.R.3 and L.R.5 Model Adjustment.

The armature is of angle section fastened to a flat spring; an iron core beneath is energised by the voltage and current coils wound upon it, the strength of the "pull" exerted on the armature by the core depending upon the current and voltage variations in service. The dynamo shunt circuit is completed through a small resistance connected across a set of points, one fixed, the other moving with the armature; when these points are closed the resistance is shorted and the field at full strength.

When the dynamo voltage reaches a predetermined value the core attracts the armature to it, opens the points and weakens the field, causing the voltage to drop. Actually, in service the points are kept vibrating and the output is therefore controlled.

Should it be necessary to make any alteration in the output the following is the procedure to be adopted:

Remove the bakelite cover, exposing the cut-out and regulator, and remove the leads from terminals A and A I, or A and L, according to the type of regulator. Now join these together and then connect a reliable voltmeter between the "dynamo pos." terminal and "earth." The engine is then run up to speed until the voltmeter "kicks," which should be about 15·5 volts. If the voltage is lower than this, release the adjusting-screw locknut and turn the screw a very little in a clockwise direction, relock it and take another test. If the output is still incorrect, the same procedure must be repeated until the correct period of vibration has been found, turning the screw in the direction required. The voltage "kick" must not be allowed to occur at a higher figure than 16·5 volts, and even that figure may only be allowed in exceptional circumstances, such as in cases where the self-starter is used a good deal without the long runs required to replenish the battery.

It must be remembered when making these tests that the dynamo is virtually running on open circuit, therefore the engine should not be raced or a misleading reading will be given. Any attempt to adjust the output by running with the battery in circuit and watching the ammeter readings will be found erratic and unreliable.

It will be seen that this regulator is much simpler to adjust than were the early models, there being but one set of points. When making any examination it is advisable to pay special attention to the main clips. These may become loose and overheated, causing the fuse to melt, leading one to look for trouble elsewhere on the supposition that it has "blown"; this, I have found, is a rather common trouble. As a general rule these regulators give little, if any, trouble in working and are a great improvement, everything being readily accessible for either inspection or adjustment.

The following are brief notes on the maintenance in service of the Lucas two-brush dynamo system previously described:

Battery.—It is important to examine the battery at least once a month, and to add distilled water to bring the acid level with the top of the separators. See that the battery terminals are tight and keep them smeared with vaseline to prevent corrosion.

Dynamo.—The dynamo calls for very occasional attention. About once a season, examine the brush gear and commutator to see that the brushes move freely and that the commutator is clean.

Regulator Unit.—The regulator unit, together with the cut-out, is incorporated in a combined cut-out, regulator, and fuse box, mounted usually on the engine side of the dash.

The cut-out and regulator units are accurately set after assembly and do not require any adjustment in service. The cover protecting these units is therefore sealed, as previously mentioned.

Ammeter Readings.—The ammeter indicates the current passing into or out of the battery. For instance, suppose the dynamo is generating

6 amperes, and that the side- and tail-lamps are in use, the lamps and ignition coil will take, say, 2½ amperes, leaving 3½ amperes for charging the battery; this is the figure shown on the ammeter.

It must be remembered, when noting ammeter readings, that, normally, during daytime running, when the battery is in good condition, the dynamo only gives a trickle charge, so that the charge reading will seldom be more than a few amperes. A discharge reading may be observed immediately after switching on the headlamps. This usually happens after a long run when the voltage of the battery is high. After a short time the battery voltage will fall and the regulator will respond, causing the dynamo output to balance the load.

When starting from cold, the driver will notice the rise of charging current until it reaches a steady maximum at a speed of, say, 20 m.p.h., after which it will remain fairly high for perhaps ten minutes or so, then fall to a steady charge which is most suitable for the particular condition of the battery.

Replacement of Fuses.—The unit is provided with two fuses, together with spares. The dynamo is protected by a fuse marked "Main" connected in the main circuit, and the fuse marked "AUX" protects the auxiliary accessories. If the dynamo fails to charge, or if the accessories fail, examine the appropriate fuse. If it has blown, locate and remedy the cause of the trouble, and fit the spare fuse provided.

See that the replacement fuse is of the same value as originally fitted (fuses are identified by the fusing current marked on a coloured paper slip inside the fuse). If the fuse blows repeatedly and the cause cannot be traced, have the equipment examined by the maker's agents.

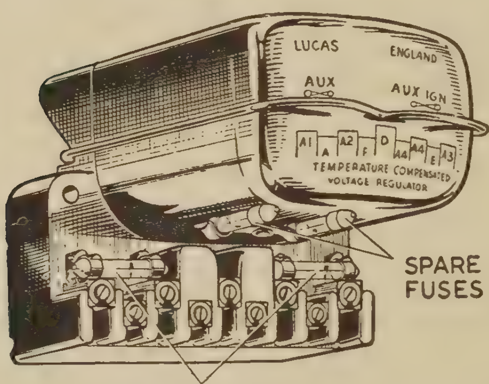


Fig. 221.—The Lucas Type R.F. 95 Control Box.

Maintenance of Modern Control-box System

The modern combined cut-out and regulator control box is regulated and in some cases sealed before it leaves the manufacturer's works, but it is usually possible in cases where the battery does not charge satisfactorily, as when the dynamo output is too low, to make suitable adjustments to the control-box unit.

Fig. 221 shows the widely used Lucas Type R.F.95 control box; the cut-out and voltage regulator units are housed under the cover, the latter being held in place by the spring clip. The unit also carries the distribution terminals for the various electrical components as well as the two fuses

for the " auxiliary " and " auxiliary ignition " systems. One fuse protects the accessories, which are connected so that they operate whether the ignition switch is " On " or " Off." The other " auxiliary ignition " fuse protects the accessories, which operate when the ignition is switched on, i.e. the stop lamp, petrol gauge, trafficators, etc. The type R.F.95 control box has temperature compensation for the voltage regulator. Fig. 223 gives the circuit diagrams of the regulator (Type L.R.T.7) which is used with the R.F.95 and also R.F.96 control boxes. The internal connections of the control box are shown in Fig. 222.

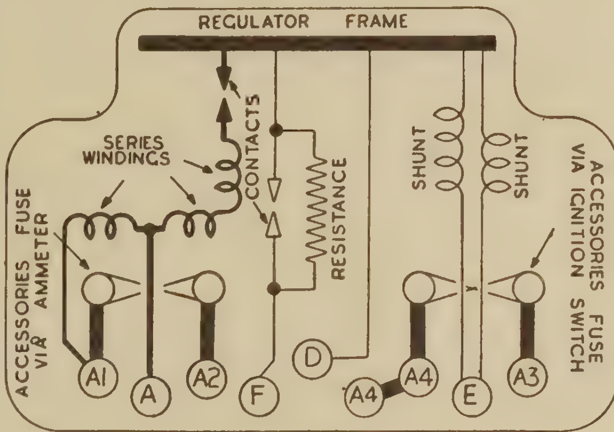


Fig. 222.—Internal Connections for Type R.F.95 Control Box.

Regulator Adjustment.—The following is the method recommended and used for regulating the R.F.95 control-box regulator used on Morris cars. It should first be ascertained that the fault is not due to a battery defect or to dynamo belt slip.

The regulator setting can be checked without removing the cover on the control box. To do this, withdraw the cables from the terminals marked "A" and " A1 " at the control box and join them together. Connect the negative lead of a 0–20-volt moving-coil voltmeter to the " D " terminal in the dynamo, and the other lead to earth.

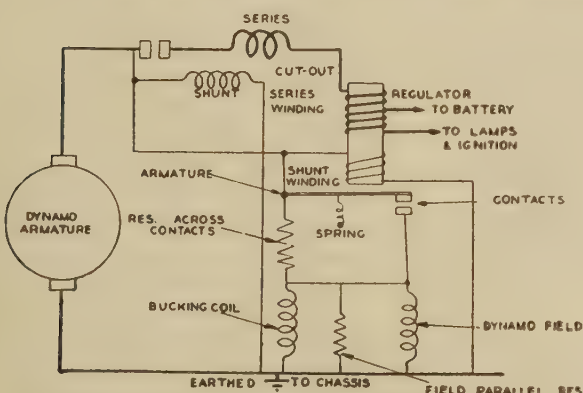


Fig. 223.—The Circuits of the Lucas Regulator, Type L.R.T.7.

Start the engine and gradually increase the speed until the voltmeter needle " flicks " and then becomes steady. This should occur at a voltmeter reading between the limits given in the accompanying table for the appropriate temperature of the regulator.

If the voltage at which the reading becomes steady occurs outside these limits, the regulator must be adjusted.

Shut off the engine, remove the control-box cover, release the lock-nut

A (Fig. 224) holding the adjusting screw B. The screw turns in a clockwise direction to raise the setting or in an anti-clockwise direction to lower the setting. Turn the adjusting screw a fraction of a turn in the required direction and then tighten the lock-nut.

VOLTAGES AND REGULATOR TEMPERATURES

Regulator Temperature		*Voltmeter Reading*
Centigrade	*Fahrenheit*	
		Volts.
10°	50°	16·1–16·7
20°	68°	15·8–16·4
30°	86°	15·6–16·2
40°	104°	15·3–15·9

When the dynamo is run at a high speed on open circuit it builds up a high voltage. When adjusting the regulator do not run the engine up to more than half throttle or a false voltmeter reading will be obtained.

Mechanical Setting.—The mechanical setting of the regulator is accurately adjusted before leaving the works, and provided that the armature carrying the moving contact is not removed the regulator will not require mechanical adjustment. If, however, the armature has been removed from the regulator for any reason, the contacts will have to be reset. To do this proceed as follows:

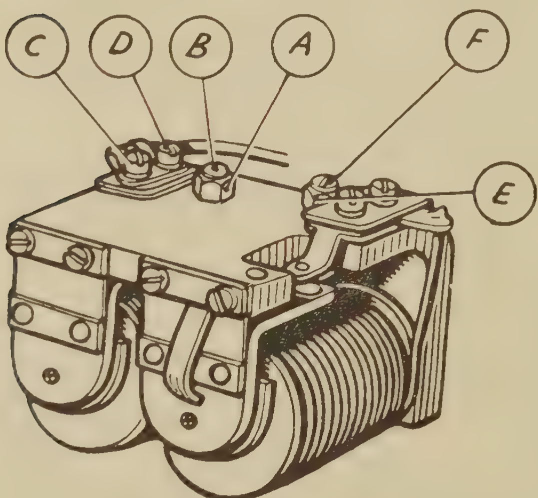


Fig. 224.—The Cut-out and Regulator Assembly (Morris).

(1) Slacken the two armature-fixing screws E (Fig. 225). Insert a ·018-in. (·46-mm.) feeler gauge between the back of the armature A and the regulator frame.

(2) Press back the armature against the regulator frame, and down on to the top of the bobbin core with the gauge in position, and lock the armature by tightening the two fixing screws.

(3) Check the gap between the underside of the arm and the top of the bobbin core. This must be ·012–·020 in. (·30–·50 mm.). If the gap is outside these limits correct by adding or removing shims F at the back of the fixed contact D.

(4) Remove the gauge and press the armature down, when the gap

between the contacts should be between ·006 in. (·15 mm.) and ·017 in. (·43 mm.).

Cleaning Contacts.—To render the regulator contacts accessible for cleaning, slacken the screws securing the plate carrying the fixed contact. It will be necessary to slacken the upper screw C (Fig. 224) a little more than the lower one, D, so that the contact plate can be swung outwards. Clean the contacts by means of fine carborundum stone or fine emery cloth. Carefully wipe away all traces of dirt or other foreign matter. Finally, tighten the securing screws.

Adjusting the Cut-out.—If it is suspected that the cutting-in speed of the dynamo is too high, connect a voltmeter between the terminals marked D and E at the control box and slowly increase the engine speed. When the voltmeter reading rises to 12·7 to 13·3 volts the cut-out contacts should close. If out of adjustment, slacken the lock-nut E (Fig. 224) and turn the adjusting screw F a fraction of a turn clockwise to raise the operating voltage and anti-clockwise to lower it.

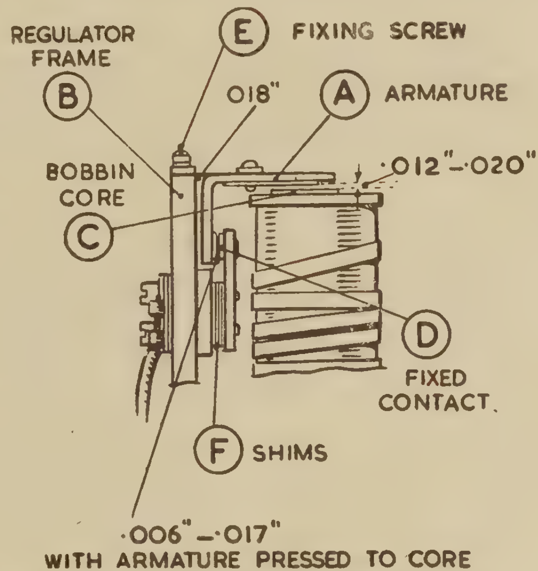


Fig. 225.—Mechanical Adjustment of the Regulator (Morris).

Locating and Remedying Faults in Two-brush Dynamos

Although these dynamos are very reliable, it may happen as a result of long service or misuse that a fault develops which affects the battery charging rate. In such cases the table given on page 224 will be found helpful in tracing the cause of the trouble and in suggesting the proper remedy.

C.A.V. Regulators for Dynamo Output

The C.A.V. regulators, used principally for commercial-vehicle electrical equipment, are of two kinds, namely, the *Compensated Voltage Control* and the *Current Voltage Control.* The former type is identified in the various models by the prefix letter B, typical units being the B1, B2, BG, BK, BJ, and BJLT. The latter type have the prefix letter C, e.g. Type CR.

As with the other *compensated voltage-control* units the C.A.V. type provides for the automatic adjustment of the charging rate in relation to the

condition of the battery. Once the dynamo has exceeded cutting-in speed, its output voltage is kept slightly in excess of the back pressure of the battery irrespective of any variation in speed. In addition, the excess voltage of the dynamo is made greater as the battery becomes discharged, and less as the battery becomes more fully charged.

In the case of the *current voltage-control* system this is so termed because a partially discharged battery is charged at a constant current until a certain

TWO-BRUSH DYNAMO FAULTS AND REMEDIES

Symptoms	*Probable Fault*	*Remedy*
Battery in low state of charge, shown by lack of power when starting.	Dynamo not charging, indicated by ammeter failing to show charge reading when running with no lights in use, due to: Broken or loose connection in dynamo circuit, or regulator not functioning correctly, causing fuse to blow.	Examine charging and field-circuit wiring. Tighten loose connection or replace broken lead. Particularly examine battery connections. Fit replacement fuse.
	Commutator greasy or dirty.	Clean with soft rag moistened in petrol.
	Dynamo giving low or intermittent output, indicated by ammeter showing low or intermittent charge reading, when running steadily in top gear, due to:	
	Loose or broken connections in dynamo circuit.	Examine dynamo wiring. Tighten loose connections or replace broken lead. Particularly examine battery connections.
	Commutator or brushes greasy.	Clean with soft rag moistened with petrol
	Brushes worn, not fitted correctly, or wrong type.	Replace worn brushes. See that brushes "bed" correctly. Fit correct-type brushes.
	Regulator not functioning correctly.	Examine and adjust as required
Battery overcharged, shown by burnt-out bulbs and frequent need for topping up.	Dynamo giving high output, indicated by ammeter giving high-charge reading when lights are in use, due to:	
	Regulator not functioning correctly.	Examine and adjust as required

[*J. Lucas, Ltd.*

battery voltage is reached, when the charging changes to constant voltage control. This allows the charging current to drop as the fully-charged state in the battery is approached until it reaches a normal trickle-charge value.

The chief advantages of *current voltage-control* is that it enables a battery to be recharged quickly and limits the dynamo output to a predetermined maximum irrespective of the external load applied, so that the possibility of a burnt-out dynamo is minimised.

Types B1 and B2 Regulators.—These are of the totally enclosed barrel type, as shown in Fig. 226. The main body A and two end caps B are permanently fixed in position by spinning over the ends of the body. In the centre is the armature C into which is screwed the brass distance piece D. These two pieces are held in a floating position by a attachment to the springs F by the contact screws G and H. Screwed into the caps at each end are the adjustable screwed contacts J and S which are locked in position after setting by the lock-nuts X and R. One pair of contacts is arranged to insert a resistance in the field circuit of the dynamo and the other pair to short-circuit the dynamo field when the dynamo is operating at high speeds. The output can be controlled over a wide range of speeds by adjustment of the pairs of contacts.

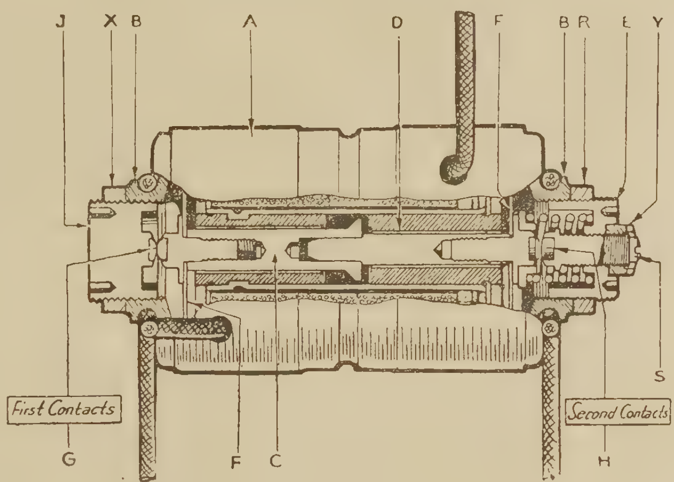


Fig. 226.—The Barrel-type Regulator.

In regard to *the testing of these regulators* the open-circuit voltage is indicated by the last figure in the regulator type formula stamped on the metal label fixed under the lock-nut R. For example, the regulator type BIE2 has the No. 2 setting, viz. 14·0 to 14·5 volts.

Types BJ, BK and BJLT Regulators.—These are all open-type regulators, i.e. their coils and contacts are not enclosed, so that they are easy to adjust or replace parts in. The former two types are combined units having both the regulator and cut-out mounted in one support frame.

The Type BJ is fitted with two regulator bobbins, the object being to divide the electrical energy in the field coils in order to allow increased excitation in the dynamo fields. The dynamos used are of the *split-field pattern.*

The three regulators mentioned *are tested on open circuit* against the values

indicated by the last group of figures of the type number stamped on the back of every regulator and easily read without removing the regulator from the base, e.g. BJ4–285. The last figure indicates an open-circuit voltage of 28·5 (to 29·0), there being plus ½ volt tolerance allowed.

For the *open-circuit test* the battery is disconnected and all load due to lamps and other accessories is switched off. A moving-coil voltmeter is then connected across the dynamo terminals and the dynamo run at a speed between 1,000–1,500 r.p.m. If the readings on the voltmeter do not fall within the prescribed voltage tolerance it is advisable to return the unit to C.A.V. or to a Service Depot. If, however, the correct tools exist and the services of a trained operator are available the regulator can be reset.

Adjustment and Setting of Barrel Regulators.—Before making any adjustments to regulators it is advisable to obtain a set of the special C.A.V. tools for barrel-type regulators. The procedure for adjustment and setting is as follows:

(*a*) Slacken back lock-nuts X, R and Y (Fig. 226). (*b*) Screw back contact J. (*c*) Screw back second contact S as far as possible. (*d*) Screw back the sleeve E. (*e*) Screw in the first contact J as far as it will go, i.e. until the armature C makes contact with the sleeve D. (*f*) Screw back the first contact about 1½ turns. (*g*) Lock the first contact screw J in this position by means of the locking nut X. (*h*) Run the dynamo at about 1,000 r.p.m. (*j*) Screw in sleeve E until voltmeter reading is within limits of setting. (*k*) Run dynamo for one minute. (*l*) Adjust sleeve E until first contact setting is not more than ·3v. above lowest limit of setting, e.g. limits of open voltage setting 15·9–16·5v. First contact setting will not be higher than 16·2v. (*m*) Lock sleeve E in position by means of lock-nut R. (*n*) Stop dynamo. Screw in contact S as far as it will go. Turn contact S back one complete turn and lock in position by lock-nut Y. (*o*) Run dynamo up to 2,000 r.p.m. Voltage setting on second contacts should be at least ·1v. above first contact setting but within the general limits of setting, e.g. limits of open-voltage setting 15·9–16·5v. Assuming first contact set at 16·2v., second contact must be set at 16·3–16·5v. (*p*) If second-contact voltage is above limit, stop dynamo and screw J in slightly. Re-check first contact setting and then proceed as in (*n*). (*q*) If second-contact voltage is below first contact, stop the dynamo and screw J out slightly. Re-check first-contact setting and then proceed as in (*n*).

Note.—The adjustment of contact S is only possible while the dynamo is stationary. If the contact is screwed up while the dynamo is running a short-circuit is set up on the dynamo, resulting in a fusing or welding of the regulator contacts.

Type C Current Voltage-control Regulator.—This is a two-bobbin regulator similar to the BJ, except that it is without cut-out and one bobbin is for voltage control and the other current control of the same circuit (Fig. 227).

Operation of the regulators is also similar to the BJ except that in order to speed up charging the current regulator is used to maintain a constant

charge from the dynamo until the battery reaches a partially charged condition. At this point the voltage regulator points commence to vibrate and do not allow the battery voltage to rise any further, as a result of which the charging rate commences to fall and the current is insufficient to open the current-regulator contacts. The current regulator, therefore, goes out of action and the dynamo is controlled by the voltage regulator. As the battery becomes more and more fully charged the current falls until a condition of trickle charge is reached. With the C-type regulator it is necessary to adjust for both voltage and current control on the respective regulators.

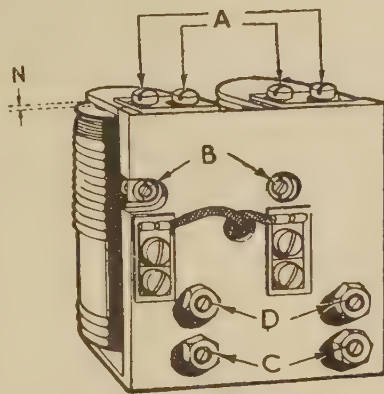


Fig. 227.—The C-type Regulator.

Testing Type C Regulator.—In this model the voltage regulator is the right-hand coil when looking at the regulator from the coil side, and the bobbin next to it is the current regulator shown in Fig. 227.

The following brief list of faults may occur from one or more causes during the useful period of regulator service. The means of recognition and correction are shown for each detail:

(1) No charge shown on ammeter.

Causes:

(*a*) Ammeter sticking.
(*b*) Bad connections in terminals.
(*c*) Main fuse blown.
(*d*) Cut-out not functioning.
(*e*) Fault in dynamo.

Items (*a*), (*b*), and (*c*) can be checked by simple inspection. Item (*d*) should be checked according to the type of cut-out with which the regulator is being used.

(2) Excessive voltage on battery with output maintained at :

19–21 amps.	..	Control Board	141/1 and 11, 155/3.
30–33 ,,	..	,, ,,	141/2, 155/4.
50–55 ,,	..	,, ,,	141/3, 4 and 5, 155/1 and 2.
60–65 ,,	..	,, ,,	141/6.
45–50 ,,	..	,, ,,	141/7 and 9.
18–20 ,,	..	,, ,,	141/8 (24-volt system).
9–11 ,,	..	,, ,,	141/10.

Causes: (*a*) Compensating winding on voltage regulator open-circuited.
(*b*) Voltage-regulator setting high.

Item (*a*) is checked by measuring the open-circuit voltage and then running the set for 15 minutes. If, at the end of this time, the open-circuit setting

is higher than it was at the commencement the compensating winding is at fault and a replacement control board should be fitted.

To check item (*b*) proceed as for (*a*). The open-circuit setting will be lower at the end of 15 minutes than at the commencement of the run. This indicates that the compensating winding is in order and the open-circuit setting can be adjusted to the correct voltage. The method of re-setting is given later.

(3) Battery becomes discharged and in this condition dynamo output does not reach

21 amps	..	Control Board	141/1 and 11, 155/3.
33 „	..	„ „	141/2, 155/4.
55 „	..	„ „	141/3, 4 and 5, 155/1 and 2.
65 „	..	„ „	141/6.
50 „	..	„ „	141/7 and 9.
20 „	(24 volts)	„ „	141/8 (24-volt system).
11 „	..	„ „	141/10.

Electrical Setting of Type C Current Regulator.—Two methods can be employed, namely:

First Method.—Connect across the batteries an appropriate load as set out below and run the dynamo at approximately 1,000 to 1,500 r.p.m. The dynamo output should then be within the limits shown:

Control Board	*Dynamo*	*Max. Load*	*Dynamo Output*
141/1 & 11, 155/3	D5LA	21 amps.	20–22 amps.
141/2, 155/4	MO	33 „	32–34 „
141/3, 4 & 5,	DW7X	55 „	54–56 „
155/1 & 2 . .	DW7X	55 „	54–56 „
141/7 & 9 . .	DW7X	50 „	49–51 „
141/8 (24-volt system)	G5524	20 „	19–20 „
141/6 . . .	MYS	65 „	64–66 „
141/10 . . .	D5L24A	11 „	10–11 „

Second Method.—Insert a feeler gauge or wooden wedge under the voltage regulator armature (right-hand armature looking from the coil side) in order to prevent the regulator functioning. Run the dynamo at 1,000 to 1,500 r.p.m. and check setting to see that it is according to the required output. To adjust the regulator, screw the lower adjusting screw C " in " to raise the setting, or " out " to lower it.

It should be noted that Type C Regulator is used with the BCK-type of cut-out, and when mounting them there should be a space between the ends of the cut-out and regulator frames of 7 mm.

Fig. 228 illustrates the Type BCK cut-out, which is of the open type. It is a complete unit in itself and can therefore be used independently of the regulator unit.

The following are the instructions for mechanical and electrical setting of this cut-out:

Mechanical Setting Armature.—(*a*) Slack off screws A attaching flat spring to frame. (*b*) Separate main contacts E and auxiliary contacts F. (*c*) Insert ·004-in. feeler between back of armature and frame. (*d*) Press armature firmly down on to the core and back against feeler. (*e*) The gap (if any) which appears between the top of frame and underside of the armature hinge spring is to be closed by inserting packing pieces until contact is established with spring. Care should be taken against using an excess thickness of packing, and so distorting the spring. (*f*) Tension screws A attaching armature spring to frame.

Note.—With the armature pressed down it should at least touch the core at front or rear, and a maximum gap of ·005 in. can be allowed between the parts not touching.

Contact Setting.—(*g*) Screw down main contacts E until gap between armature tip and core is ·02 in. with armature held down. (*h*) With ·008 in. feeler between main contacts E, hold armature down and adjust auxiliary contacts F to touch. (*j*) Lock both contacts E and F in above positions. (*k*) With contacts in open position, gap between armature tip and core should measure ·05 in. This figure is obtained by bending armature stop O.

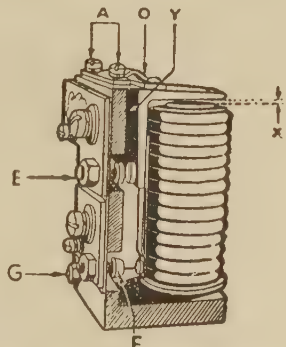


Fig. 228.—Type BCK Cut-out.

Note.—Certain types of BJ cut-outs, e.g. as fitted to the 148 Control Board, will be found fitted with two pairs of auxiliary contacts instead of one pair as standard. Both pairs must be set as described above in (*h*) and (*j*).

Electrical Setting.—The cut-out voltage setting is obtained from the last group of figures in the type number stamped on the back of the cut-out and which indicates the minimum open-voltage regulator setting, e.g. BJ4–285. As the last figure in the group is decimal the resultant setting can thus be determined and from the example it would be 28·5 volts. From the minimum regulator setting is obtained the cut-out setting which must be from 1–1·5 volts below, thus again referring to the example the voltage setting for cut-out BJ4–285 will be 27–27·5 volts. (*l*) Start dynamo and gradually speed up until a peak voltage is registered on the voltmeter.

American Dynamo Regulator Devices

A popular and widely used system for American car dynamo output regulators is the *current and voltage device* to which reference has been given earlier in this chapter. Typical regulators are the Autolite and Delco-Remy ones; the latter are dealt with later in this chapter.

The general principle employed is to use three solenoid units, namely (1) the cut-out, (2) the voltage coil, and (3) the current coil. The cut-out

or, as it is termed, the "circuit-breaker" is identical in principle and layout to others described earlier.

The current regulator device limits the maximum current output. Thus in a typical modern car, e.g. the Kaiser-Frazer models, when the dynamo output reaches a maximum value, at 34 to 36 amperes, the regulator points (contacts) are opened and a fixed resistance is thereby inserted in the generator field circuit to reduce the current value. As soon as the output falls the contacts close and the resistance is short-circuited, or cut out, so that the output rises. These cycles occur so rapidly that the contacts vibrate at a high frequency, thus maintaining the current output constant.

The voltage regulator device maintains the voltage of the electrical system constant within close limits, and its principle is similar to that previously described for constant-voltage systems. When the voltage rises to a predetermined value the regulator contacts vibrate, thus cutting in and out a fixed resistance in the field circuit. For a 6-volt battery system the voltage regulator would maintain the voltage at 7·2 to 7·5.

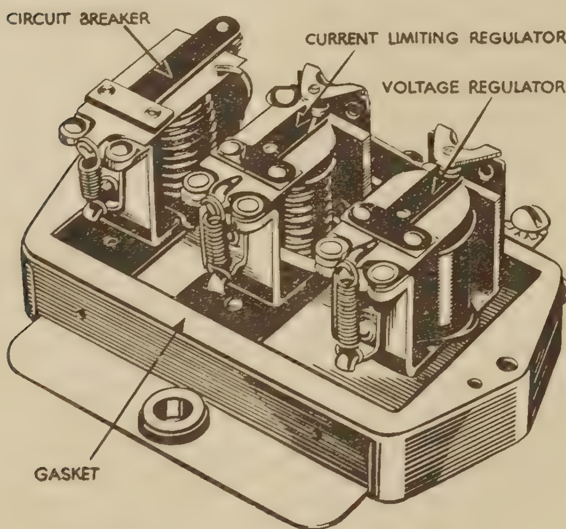


Fig. 229.—The Current and Voltage Regulator Unit.

The method of checking the regulators is as follows:

(i) *Voltage Regulator Test*

(*a*) Connect a 0–10-volt range voltmeter from the battery terminal marked B on unit to the regulator frame (ground or earth).

(*b*) See that the regulator is at the normal temperature and run the engine at a speed equivalent to 30 m.p.h. in top gear. The dynamo speed would be about 2,500 r.p.m. at this road speed.

(*c*) The charging voltage as read from the test voltmeter should be 7·2 to 7·5 volts at 70° F.

(*d*) If any adjustment is necessary, bend the voltage regulator spring bracket, as shown in Fig. 230, in order to increase or reduce the voltage to 7·35. Increased tension increases the voltage. Finally, recheck with the cover in place.

(*e*) The air gap seldom varies, but it should be checked, as should the contacts gap. The values should be as follows:

Armature air gap: ·048–·052 in.

Contacts gap (minimum): ·012 in.

(2) *Current Regulator Test*

(*a*) Using the voltmeter and ammeter connections as for the voltage-regulator test, connect a variable resistance or bank of lamps across the battery terminals.

(*b*) With the engine speed equivalent to 35 m.p.h. (dynamo speed 3,000 r.p.m.) and the regulator warm, adjust the resistance across the battery until the voltage falls to 6·6. At this voltage the current regulator should limit the dynamo output to between 34 and 36 amperes, with the cover on the regulator.

(*c*) Adjust the output, if necessary, by bending the spring hanger bracket in a similar manner to that shown in Fig. 230 for the voltage regulator. Increased tension increases the output current.

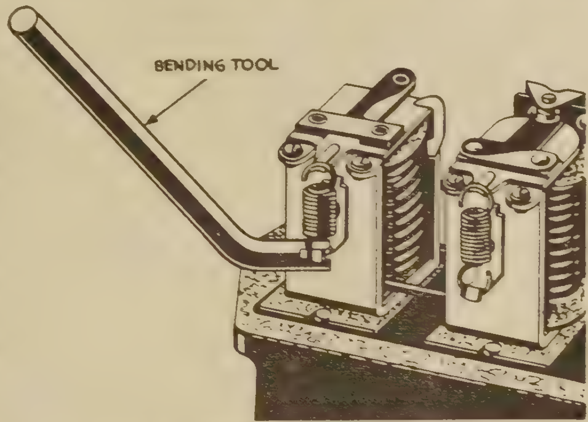


Fig. 230.—Method of Adjusting Regulator.

(*d*) It is unlikely that the air gap will have altered, but the armature and contacts gaps should be checked, their correct values being:

Armature air gap: ·048–·052 in.

Contacts gap (minimum): ·012 in.

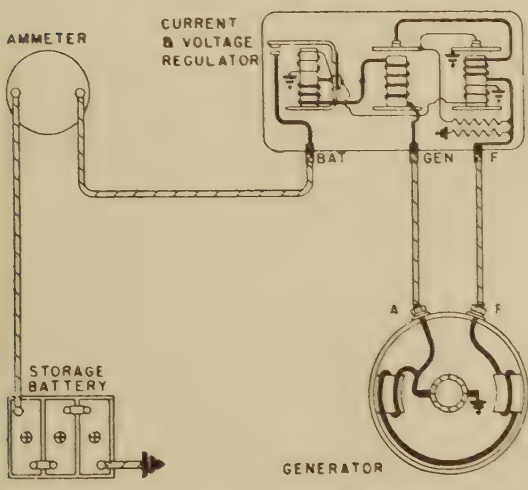


Fig. 231.—Delco-Remy Current and Voltage-regulating System.

Delco-Remy Current and Voltage Regulator

The general arrangement of this widely used charging circuit regulator is shown in Fig. 231. With this regulator there is both a current and a voltage control circuit, but *only one of these operates at the same time*. If the electrical load requirements are large and the battery is low, the current regulator will operate to prevent the generator output from exceeding its safe maximum; the voltage is not sufficient to cause the voltage regulator to operate. However, if the electrical load is reduced, or the battery specific

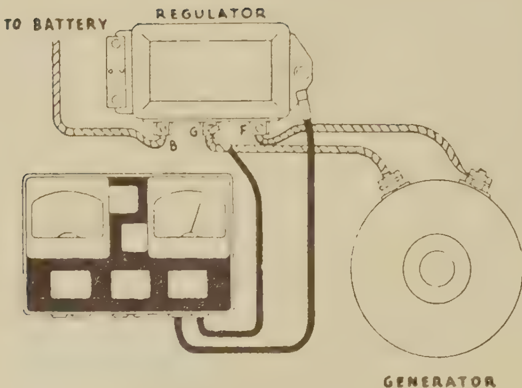


Fig. 232.—Checking Cut-out Relay Closing Voltage.

gravity increases sufficiently, the line voltage will increase to a value sufficient to cause the voltage regulator to operate.

When this happens, the generator output begins to taper off and it falls below the value required to operate the current regulator. The current regulator, therefore, stops operating; all regulation is dependent upon the voltage regulator.

Two resistances are in use on many current and voltage regulators. They are connected in parallel into the generator field circuit when the current regulator points open to give a lower value of resistance. When the voltage-regulator points open, only one resistance is inserted into the generator field, and this provides a higher value of resistance. The reason for this is that the voltage regulator must employ a higher value resistance than the current regulator; it requires more resistance in the generator field to reduce the output of the generator to a low value than to merely prevent the output from increasing beyond the safe maximum of the generator.

Maintenance of Delco-Remy Regulator Unit.—The cut-out relay, current-regulator, and voltage-regulator settings should be checked as explained hereafter. Check the regulator mounting and the lead connections to be sure they are tight. The cover must be assembled tightly, and the rubber gasket between the cover and regulator base must be in place.

To Check the Closing Voltage of the Cut-out Relay.—Connect a voltmeter between the "GEN" terminal and the regulator base as shown in Fig. 232. Slowly increase the

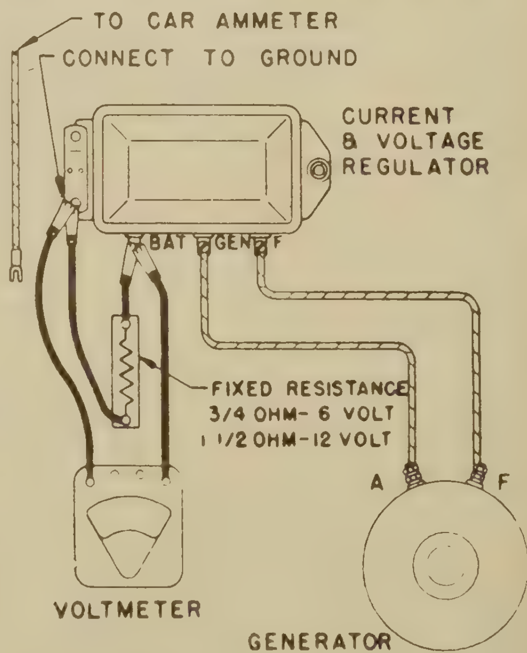


Fig. 233. Voltage-regulator Check (Fixed-resistance Method).

generator speed and note the voltage at which the relay points close.

To Check the Current Regulator Setting.—Remove the regulator cover and connect a jumper lead across the voltage-regulator contact points and connect a test ammeter into the circuit at the "BAT" terminal as shown in Fig. 234. With the regulator at operating temperature, turn on the lights and accessories to prevent high voltage, run the generator at medium speed and note the current setting. Another method of checking the current-regulator setting which does not require removal of the regulator cover is to connect the test ammeter into the circuit as above, use the cranking motor for about 15 seconds with the ignition switch off, turn on the lights and accessories, start the engine and then very quickly note the current setting. The current regulator will operate until the voltage increases to a value which will cause the voltage regulator to operate and begin to taper down the output.

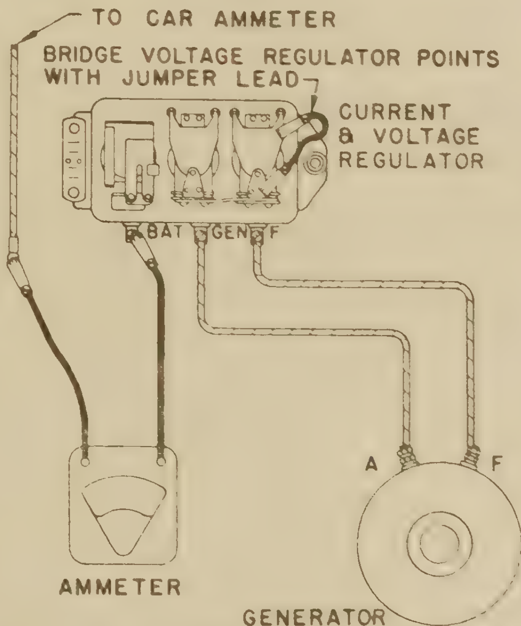


Fig. 234.—Method of Checking Current-regulator Setting.

To Check the Voltage-regulator Setting.—Either of two methods may be used—the fixed-resistance or the variable-resistance method. With the fixed-resistance method, disconnect the lead from the "BAT" terminal of the regulator and connect a $\frac{3}{4}$-ohm fixed resistance ($1\frac{1}{2}$ ohm for 12-volt) and a voltmeter from this terminal to the regulator base as shown in Fig. 233. The resistance must be capable of carrying 10 amperes continuously and must not change in value as its temperature changes. Note voltage setting with the regulator at *operating temperature* with the generator running at medium speed. The regulator cover must be in place.

In the *variable-resistance method* a variable $\frac{1}{4}$-ohm resistance, an ammeter, and voltmeter are used. The ammeter and variable resistance are connected in series in the charging circuit at the "BAT" terminal and the voltmeter is connected from the "BAT" terminal to the regulator base. The dynamo should be operated at medium speed with the regulator at operating temperature and the cover in place. If less than 8 amperes is obtained the lights should be switched on to increase the dynamo output. Then, cut in the resistance slowly until the generator output is reduced to be-

tween 8 and 10 amperes. Then slow the dynamo to "idle," bring it back to speed and note the voltage setting.

Note.—It is important that the dynamo should never be run or tested on open circuit or serious damage will be done to the dynamo or regulator.

Regulator Adjustment.—The Delco-Remy *cut-out relay closing voltage* is adjusted by bending up on the flat spring post to increase the tension of the flat spring and thus *increase the closing voltage.* Bending down on the spring post lowers the closing voltage.

The *current-regulator setting* is adjusted by bending the lower spring hanger of one spring down to increase the current setting, or up to lower it. Only one spring should be treated in this way.

The voltage-regulator setting is adjusted exactly the same as the current-regulator setting. After each change of voltage replace the regulator cover, reduce the generator speed until the relay points open, and then bring the generator back to its speed and note the voltage setting. In addition, if the voltage is checked by the variable-resistance method, the variable resistance must be readjusted to maintain the 8 to 10 amperes output. If a complete adjustment of the regulator is needed it is advisable to remove it from the vehicle and have it attended to by a Delco-Remy service agent.

Quick-check Method for Generator-regulator System.—The following notes relate to quick checks on the Delco-Remy electrical systems of motor vehicles to determine whether or not the units are operating normally and if they are not to help locate the source of the trouble:

(1) *A fully charged Battery and a High Charging Rate.*—Connect test ammeter into the circuit at the "BAT" terminal of the regulator and disconnect the lead from the "F" terminal of the regulator to determine whether it is the regulator or some other unit in the electrical system which is causing the condition. This takes the regulator completely out of the generator field circuit and the output should normally drop off. If the output does not drop off with the generator operating at medium speed and the "F" terminal lead disconnected, the generator field is earthed, either in the wiring harness or in the generator itself.

If the output does drop off as the "F" terminal lead is disconnected, check the regulator for a high voltage setting. Remember, however, that where temperatures are high, the charging rate may also be high, even though the battery is charged and the voltage-regulator setting is satisfactory for normal climatic conditions. Therefore, in hot climates it may be necessary to reduce the voltage-regulator setting to as low as 6·9 volts (13·7 on 12-volt system) in extreme cases. The cut-out relay must likewise be reduced to 6·2–6·6 volts (12·3 on 12-volt system), so that it still operates at a lower voltage than the regulator.

(2) *With a Low Battery and a Low or No-charging Rate*, check the circuit for loose connections or defective leads, since these produce high resistance which causes the voltage regulator to operate as though the battery were fully charged even though the battery is in a discharged condition. Next, momentarily earth the "F" terminal of the regulator with the generator

operating at a medium speed. If the output increases, check the regulator for oxidised or dirty contact points, or a low voltage setting. If the output remains low, check the generator as the source of trouble. If no output at all is obtained, make sure the cut-out relay is closing, since it could be that it is not closing due to a high closing voltage setting or an open voltage winding.

Burned Resistance Units, Regulator Winding or Fused Contacts result from *open-circuit operation* or high resistance in the charging circuit. With any of these conditions, check the vehicle wiring carefully.

Maintenance of Lucas Dynamos

The following notes refer to the more recent models of Lucas dynamos in service. These dynamos operate for considerable mileages with very little

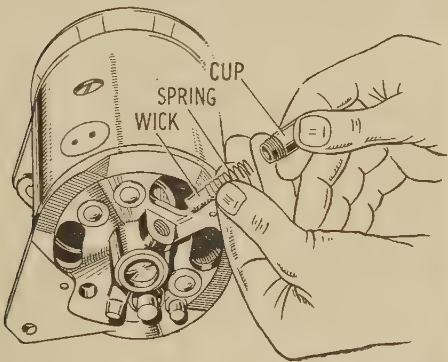


Fig. 235.—Lubricator of the Felt-pad Type (Hillman).

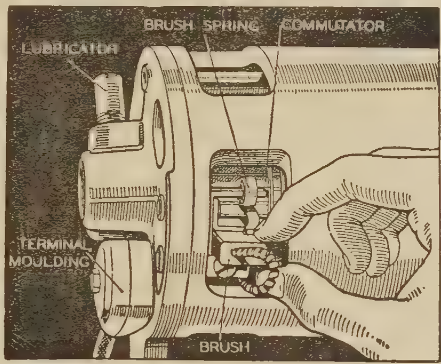


Fig. 236.—Removing a Brush.

attention beyond lubrication and occasional inspection of the commutator and brush gear.

All dynamos are sent out from the works with the bearings packed with grease which lasts for a considerable time. About every 10,000 miles, or when the car is taken down for a general overhaul, it is advisable to have the machine dismantled, for cleaning and adjustment, and repacking the bearings with grease.

Dynamos of the type illustrated are provided with a lubrication wick at the commutator end of the machine (Fig. 235). About once every year unscrew the cap of the lubricator and, if the wick is dry, refill cap with vaseline.

Some dynamos have oilers or greasers to enable one to give them a little additional lubrication. Oilers should be given a drop of oil every 1,000 miles. Greasers may be given one turn every 500 miles, and should be recharged when empty with a good-quality high-melting-point grease.

With some machines one will find a flap marked "GREASE" at the commutator end of the machine. Periodically, say when the engine is being decarbonised, move aside the flap and add a very small quantity of high-melting-point grease.

About once a year. remove the metal cover from the dynamo for inspec-

tion of the commutator and the carbon contacts, or brushes as they are called. Take care not to lose the dished nut when removing the cover-fixing screw, as the cover is liable to spring open when the screw is released—in some cases the cover can be slid off the end of the machine after slackening the screws.

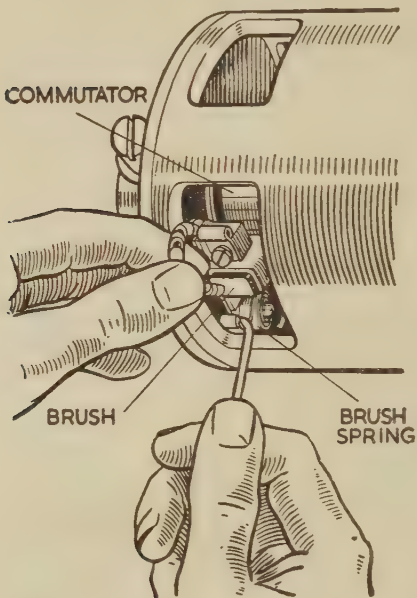


Fig. 237.—Releasing Brush on Model C45PVS Dynamo.

The brushes must make good, firm contact with the commutator. With some machines, the brushes are held in boxes by spring levers. Hold back the spring lever as shown (Fig. 236), and at the same time move the brush to see that it is free to slide in its holder. If there are any signs of sticking, remove it from its box and clean it with a cloth moistened with petrol. With other types, the brushes are secured to spring arms. Lift the levers carrying the brushes and see that they move freely on their pivots.

To release the brushes in the later Type C45PVS dynamo, hold back the brush spring with a piece of wire as shown in Fig. 237.

After removing brushes for cleaning or any other purpose, care must be taken to replace them in their original positions, otherwise they will not " bed " properly on the commutator.

Next examine the commutator. It should be clean and free from any trace of oil or dirt and should have a highly-polished appearance. The best way to clean a dirty or blackened commutator is by pressing against it a fine dry duster and getting someone to turn the engine over slowly by hand (Fig. 238). If the commutator is very dirty, the duster may be moistened with petrol.

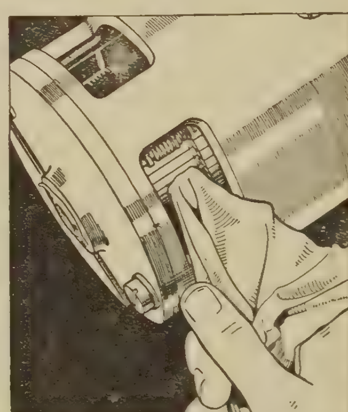


Fig. 238.—Cleaning the Commutator.

Belt-driven Dynamos

With belt-driven dynamos, the driving belt should be kept fairly taut and adjusted from time to time to take up the slack. Care should be taken, however, not to over-tighten the belt, and also to see that the machine is properly aligned: otherwise undue strain will be thrown on the dynamo bearings.

The usual method of adjusting the dynamo belt tension is to arrange for the dynamo support bracket to hinge downwards so that it can be lowered to increase the tension of the belt, afterwards being locked securely by the two hinge bolts and a third bolt and nut in a slotted-plate type of arm. Fig. 239 illustrates the method as used on Morris cars. In this case the belt tension is adjusted by slackening the bolts of the dynamo cradle at the three places indicated by the arrows. The belt tension should be checked every 3,000 to 4,000 miles.

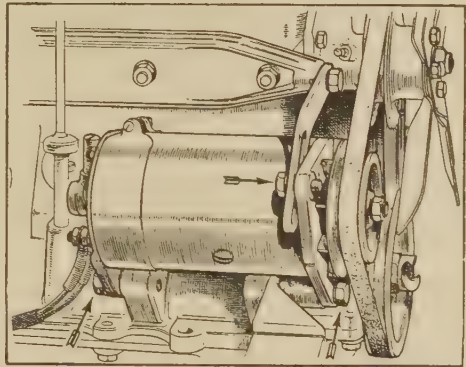


Fig. 239.—Method of Tensioning the Dynamo Belt (Morris).

Usually the belt tension is correct when there is about $\frac{1}{2}$ to $\frac{3}{4}$ in. lateral play on the longer driving side.

If *the belt bottoms on the vee pulleys* it will slip no matter how tight it may be, so that the dynamo will then run at too low a speed and will not give the correct charging current. If the bottoms of the vee grooves on the pulleys are found to be brightly polished this is a sign of belt bottoming; a new belt must then be fitted.

The dynamo output is accurately set before leaving the works, to suit the requirements of the equipment fitted on the car, and in normal service the battery will be kept in good condition. If, due to very special running conditions, however, one should find that the battery is not kept in a charged condition, or is being excessively overcharged, the adjustments should be made by a skilled electrician.

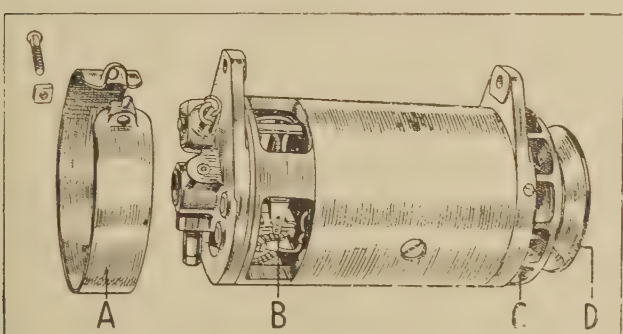


Fig. 240.—The 12-volt Ventilated Dynamo used on Typical British Cars, showing: A, the Brush-gear Cover; B, the Brush Gear; C, the Cooling Fan; and D, the Driving Pulley.

The Ventilated-type Dynamo

The output from a given size of dynamo, as in the case of practically all electrical machinery, is limited by the question of heat dissipation. The ever-increasing demand for more output is being met by a range of dynamos which are arranged for internal cooling.

The Lucas method of ventilation is to draw air through the dynamo, by means of a centrifugal fan incorporated with the driving pulley (Fig. 240).

The cover band at the commutator end of the machine and the driving end bracket have louvres cut in them so that air can be drawn through the machine from the commutator to the driving end. As a result of this ventilation the machine runs cooler and gives as much as a 25 per cent. increase of output over the same size non-ventilated dynamo.

An " exploded " view of the Lucas Type P32/0 ventilated dynamo, as fitted on many Vauxhall cars, is given in Fig. 241. This is of the two-brush compensated-voltage pattern used in conjunction with the R.F.91 type control box. The dynamo is belt driven to run at 1·328 times engine speed.

In addition to internal cooling, it is advantageous if the dynamo is mounted in a favourable position on the engine, where it receives the

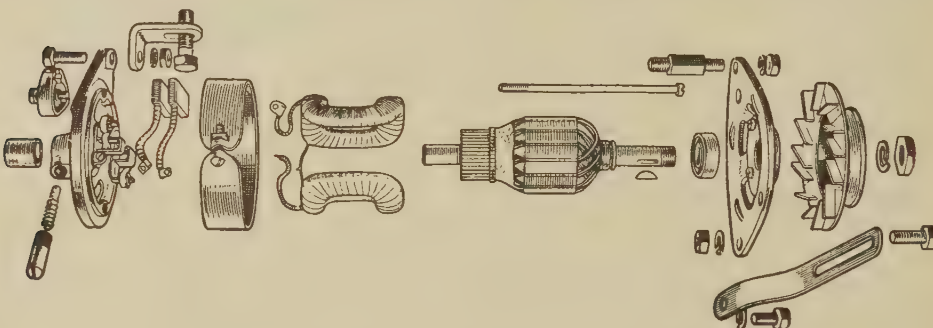


Fig. 241.—Exploded View of Ventilated Dynamo (Vauxhall).

benefit of the air stream from the fan, or, if no fan is fitted, the air stream through the radiator.

Tests have shown that the best arrangement is when the dynamo is mounted at the front of the engine and is belt-driven so that it forms a triangular drive with the fan. In this position the dynamo receives the benefit of the air stream from the blade tips of the fan. It should be noted that a dynamo mounted immediately behind the centre of the fan is not cooled by it, as the air in this area is relatively " dead."

Care of the Brushes

It is important to maintain the brushes in the correct condition and position in order to get the best out of the generator.

The cover plate of the generator having been removed, the brushes should be moved in their guides to see that they are free and true.

Whilst the engine is running observe whether there is excessive sparking —this is a sign of a dirty commutator or incorrect position of the brushes.

The brushes should all be tested for free sliding action. Test the brush by pulling each flexible lead and releasing it, observing whether it returns without sluggishness.

The brushes should be clean and " bed " over the whole surface; that is, the face in contact with the commutator should appear uniformly polished. Dirty brushes may be cleaned with a cloth moistened with petrol.

If any of the brushes become so badly worn that it is necessary to replace them.

The brush springs should be inspected occasionally to see that they have sufficient tension to keep the brushes firmly pressed against the commutator when the machine is running. It is particularly necessary to keep this in mind when the brushes have been in use for a long time and are very much worn down.

Bedding the Brushes.—To obtain a correct charging rate, all brushes must be well seated on the commutator. Brushes are noisy also if they are not properly seated. It is usually a comparatively simple matter to thread a strip of No. 00 sand-paper or sand-cloth round at least a portion of the commutator with the rough side next to the brush or brushes. A few strokes with the sand-cloth correctly form the brush seat. Another method is to wrap a strip of sand-paper or sand-cloth snugly around the commutator, gluing the overlapping edges of the sand-paper to secure it. Much time can be saved in this operation by passing a heated soldering iron over the paper to dry the glue. The end housing may then be replaced and all three brushes properly sanded at the same time.

When installing new brushes in place of worn ones on the flexible type of brush arm, always assemble the brush on the inside of the phosphor-bronze blade. Incorrect assembly may cause the charging rate to be excessive.

Do not bend either intentionally or carelessly the phosphor-bronze blade upon which the brush is mounted so that the brush sets at a greater angle than 92° with the phosphor-bronze blade. An unsatisfactory charging rate will result from incorrectly formed brush arms.

Dismantling a Modern Car Dynamo

The method of dismantling for servicing purposes a modern car dynamo is well illustrated in the case of the 1951 Lucas C45PVS dynamo shown in Fig. 242. This dynamo is fitted to home and export models of the Morris Six cars, for which the following instructions apply.

To dismantle the dynamo, remove the driving pulley with a pulley tool. Remove the cover load, hold back the brush springs, and remove the brushes from their holders.

Unscrew and withdraw the two long through bolts from the driving end. Remove the nut, spring washer, and flat washer from the smaller (field) terminal on commutator end bracket, and remove the bracket from the armchair yoke.

The driving-end bracket, with armature, can then be lifted clear of the yoke. Care should be taken not to lose the spring and cup from the end of armature shaft. The driving-end bracket, which on removal from the yoke has withdrawn with it the armature and armature shaft ball bearing,

need not be separated from the shaft unless the bearing is worn; in this case the armature must be taken off the end bracket with the aid of a hand press.

Servicing the Dynamo

The servicing of the dynamo shown in Fig. 242 necessitates inspection and if necessary attention to (1) *The Bushes*, (2) *The Commutator*, (3) *The Field Coils*, (4) *The Armature*, (5) *The Bearings*.

(1) **The Brushes.**—First check to see whether the brushes are sticking

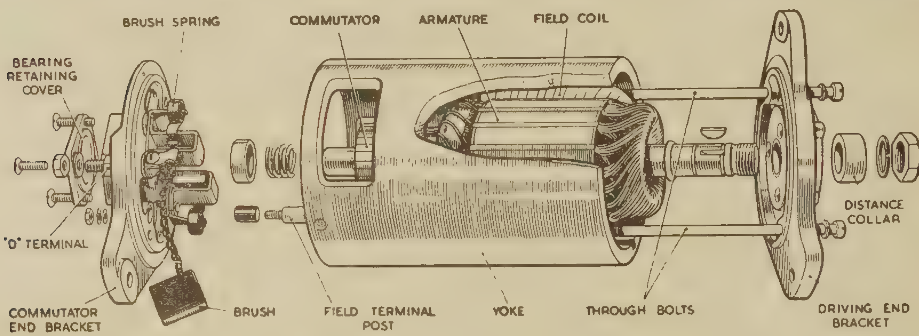


Fig. 242.—The Lucas C45PVS Dynamo, as used on Morris Six and other Modern Cars

in their guides. If necessary clean them with petrol and lightly ease the sides with a flat fine-cut file.

Always replace the brushes in their original position, polishing with a smooth file.

Test the brush-spring tension with a spring scale if available. The correct tension is 20–25 ozs. Fit a new spring if the tension is low.

If the brushes are worn so that the flexible lead is exposed on the running face, new brushes must be fitted. Brushes are pre-formed so that bedding to the commutator is unnecessary.

(2) **The Commutator.**—A commutator in good condition will be smooth and free from pits or burned spots. Clean the commutator with a petrol-moistened cloth. If this is not satisfactory use a strip of fine emery cloth, holding it on the commutator whilst the armature is rotated. If badly worn it will be necessary to turn the commutator on a lathe, and then undercut the mica in the manner described in detail later.

(3) **The Field Coils.**—These should be tested in place, *using an ohmmeter*. The correct reading should be 6 to 6·3 ohms. If this is not obtainable, connect a 12-volt battery with an ammeter in series between the field terminal and dynamo yoke. The ammeter should read $\frac{12}{6} = 2$ to $\frac{12}{6{\cdot}3} = 1{\cdot}9$ amperes.

If no reading is obtained this indicates that the coils are open-circuited, and if not easily repaired they should be replaced.

To test for earthed field coils unsolder the end of the field winding from the earth terminal on the dynamo yoke and with a test lamp connected from the supply mains test across the field terminal and earth. If the lamp lights this shows that the field coils are earthed and they should therefore be replaced.

To replace the Field Coils.—When replacing field coils carry out the procedure outlined below, using an expander and wheel-operated screwdriver (Figs. 243 and 244).

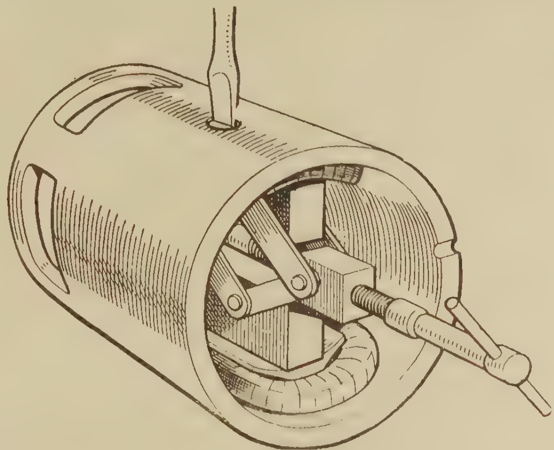


Fig. 243.—The Expander Tool used for Fitting the Pole Pieces Correctly.

(*a*) Remove the insulation piece which is provided to prevent the junction of the field coils from contacting the yoke.

(*b*) Mark the yoke and pole shoes in order that they can be fitted in their original positions.

(*c*) Unscrew the two pole-shoe-retaining screws by means of the wheel-operated screw-driver.

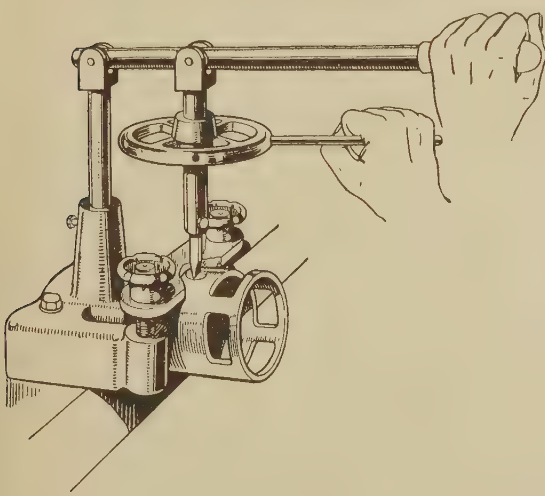


Fig. 244.—Wheel-operated Screw-driver for the pole Pieces Attachment Screws.

(*d*) Draw the pole shoes and coils out of the dynamo yoke and lift off the coils.

(*e*) Fit the new field coils over the pole shoes and place them in position inside the yoke. Take care to ensure that the taping of the field coils is not trapped between the pole shoes and the yoke.

(*f*) Locate the pole shoes and field coils by lightly tightening the fixing screw.

(*g*) Insert the pole-shoe expander, open it to the fullest extent, and tighten the screws.

(*h*) Finally, tighten the screws by means of the wheel-operated screw-driver and lock them by caulking.

(*i*) Replace the insulation piece between the field coil connections and the yoke.

(4) **The Armature.**—The testing of the armature winding requires the use of a voltage-drop test and growler. (These are dealt with later in this chapter.) If these are not available the armature should be checked by substitution. No attempt should be made to machine the armature core or to true a distorted armature shaft.

(5) **The Bearings.**—Bearings which are worn to such an extent that they will allow side movement of the armature shaft must be replaced.

To replace the bearing bush at the commutator end proceed as follows:

(*a*) After removing the four screws on end plate, press the bearing bush out of the commutator end bracket.

(*b*) Press the new bearing bush into the end bracket, using a shouldered mandrel of the same diameter as the shaft which is to fit in the bearing (Fig. 245).

Note.—Before fitting the new bearing bush it should be allowed to stand completely immersed for twenty-four hours in thin engine oil. This will allow the pores of the bush to become filled with lubricant.

In another type bearing bush high-melting-point grease is used to pack it.

(*c*) Locate the bearing in the housing and use a hand press to force it home. Finally, refit the square plate with the four fixing screws.

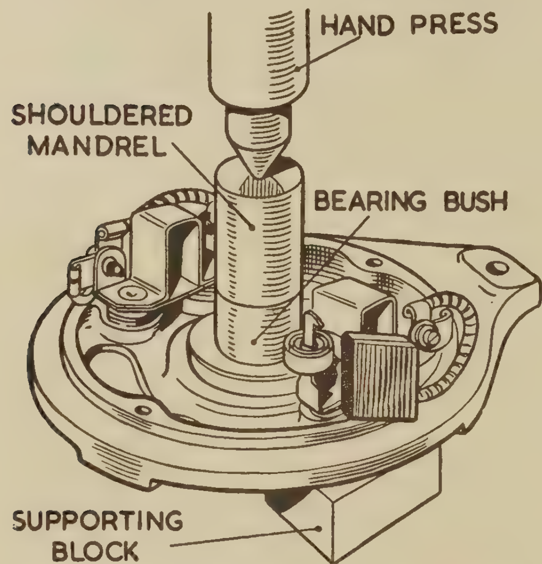


Fig. 245.—Fitting a New Bronze Bearing Bush in Dynamo. Note one of the two Supporting Blocks.

The ball bearing at the driving end is replaced as follows:

(*a*) Knock out the rivets which secure the bearing retaining plate to the end bracket and remove the plate.

(*b*) Press the bearing out of the end bracket and remove the corrugated washer, felt washer, and oil-retaining washer.

(*c*) Before fitting the replacement bearing see that it is clean and pack it with a high-melting-point grease.

(*d*) Place the oil-retaining washer, felt washer, and corrugated washer in the bearing housing in the end bracket.

(*e*) Locate the bearing in the housing and press it home by means of a hand press.

(*f*) Fit the bearing retaining plate. Insert the new rivets from the inside of the end bracket, and open the rivets by means of a punch to secure the plate rigidly in position.

Lubrication Note.—When the dynamo is reassembled lift out the felt wick and spring and refill the cap with high-melting-point grease. Then replace the spring and wick and screw the lubricator in position in the end bracket.

Testing the Lucas Type C45PV Dynamo

The methods used for testing this dynamo, as fitted to the Morris Six, and recommended by the equipment suppliers and Morris Motors, Ltd., are as follows.

Tests Made on Vehicle.—(*a*) Make sure that belt slip is not the cause of the trouble. The belt should be capable of being deflected approximately ½ in. at the centre of its longest run between two pulleys with moderate hand pressure. If the belt is too slack, tightening is effected by slackening the long bolt on which the dynamo pivots, and the bolt securing the slotted adjustment link to the crankcase, and gently pulling the dynamo outwards by hand until the correct tension is obtained. The slotted link bolt must then be tightened, followed by the lower bolt.

(*b*) Check that the dynamo and control box are connected correctly. The dynamo terminal "D" should be connected to the control box terminal "D," and the dynamo terminal "F" connected to control-box terminal "F."

(*c*) After switching off all lights and accessories, disconnect the cables from terminals of dynamos marked "D" and "F" respectively.

(*d*) Connect the two terminals with a short length of wire.

(*e*) Start the engine and set to run at normal idling speed.

(*f*) Clip the negative lead of a moving-coil-type voltmeter, calibrated 0–20 volts, to one dynamo terminal and the other lead to a good earthing point on the dynamo yoke.

(*g*) Gradually increase the engine speed, when the voltmeter reading should rise rapidly and without fluctuation. Do not allow the voltmeter reading to reach 20 volts. Do not race the engine in an attempt to increase the voltage. It is sufficient to run the dynamo up to a speed of 1,000 r.p.m.

If there is no reading, the brush gear should be checked.

If the reading is low, e.g. 1 volt, the field winding may be faulty.

If the reading is about 5 volts this indicates a defective armature winding.

(*h*) Remove dynamo cover band and examine brushes and commutator. Check brushes ior free sliding movement and for excessive wear. If the brush flexible lead has become exposed on the running face, new brushes must be fitted. If the commutator is blackened or dirty, clean it by holding a petrol-moistened cloth against it while the engine is turned slowly by hand-cranking. Re-test the dynamo; if there is still no reading on the voltmeter there is an internal fault and the complete unit should be replaced, if a spare is obtainable.

If the dynamo is in good order, remove the temporary link from between the terminals and restore the original connections, taking care to connect

the dynamo terminal "D" to the control box terminal "D" and the dynamo terminal "F" to the control-box terminal "F." Remove the lead from the "D" terminal on the control box and connect the voltmeter between this cable and good earthing point on the vehicle. Run the engine as before. The reading should be the same as that measured directly at the dynamo. No reading on the voltmeter indicates a break in the cable to the dynamo. If the reading is correct test the control box.

The Simms Dynamo and Control Box

In reference to the wiring diagram of the A.E.C. vehicle, given previously in Fig. 196, it is now proposed to deal with the dynamo and com-

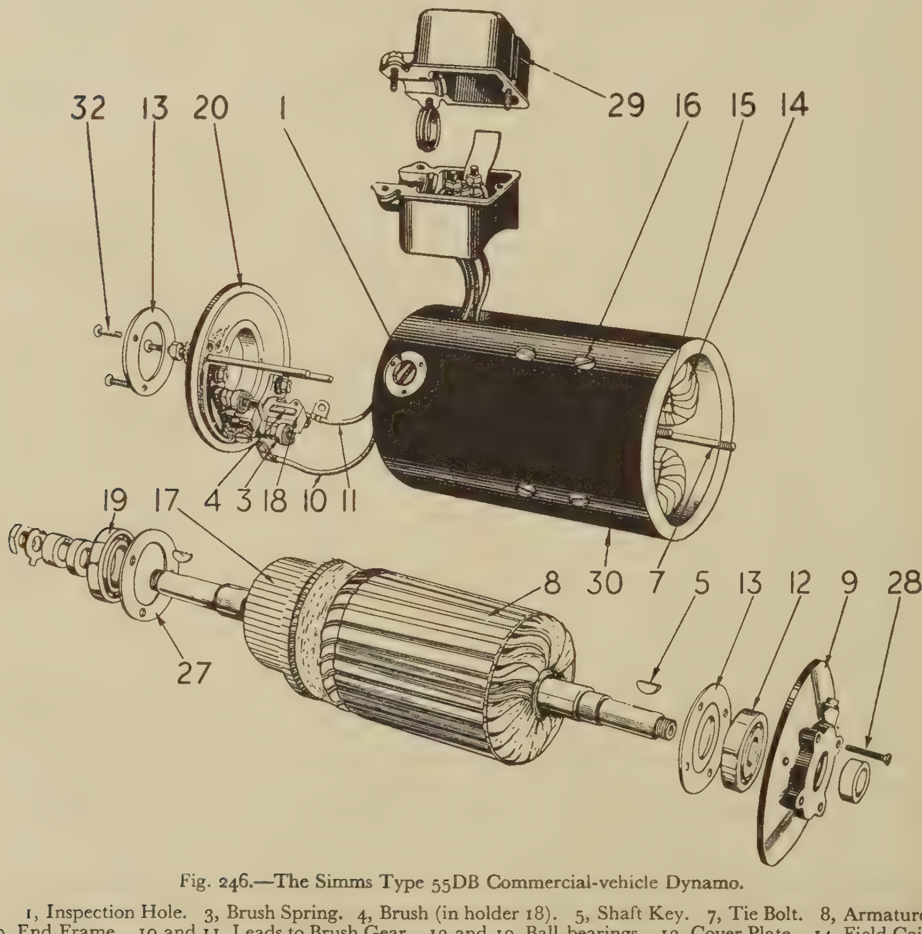


Fig. 246.—The Simms Type 55DB Commercial-vehicle Dynamo.

1, Inspection Hole. 3, Brush Spring. 4, Brush (in holder 18). 5, Shaft Key. 7, Tie Bolt. 8, Armature. 9, End Frame. 10 and 11, Leads to Brush Gear. 12 and 19, Ball-bearings. 13, Cover Plate. 14, Field Coil. 15, Field Coil. 16, Pole-securing Screws. 17, Commutator. 18, Brush Holder. 19, Ball Bearing. 20, End-cover Plate. 27, End Plate. 28, End Frame Screw. 29, Terminal Box. 30, Cylindrical Frame. 32, End-plate Screws.

bined regulator and cut-out unit, shown in the illustration of the Simms Control Unit (Fig. 201).

The Dynamo.—The Type 55DB Simms dynamo, shown dismantled in Fig. 246, is of 24-volt output and is driven by twin V-belts in some instances and from the timing chain in others.

To dismantle the Dynamo.—After removal from the engine first remove the half-coupling or belt pulley—whichever drive is used—from the armature shaft with a pulley drawer.

Remove the shaft key (5), using a suitable punch and hammer.

Remove the tail-shaft nut, locking washer, collars, and key.

Then remove the commutator end plates (13) and (27).

Disconnect the leads in the terminal box after removing cover (29). Mark the leads so that they can be put back correctly.

Remove terminal box.

Take off the three commutator-end bearing cap retainer screws (32).

Remove the tie bolts (7).

Remove the commutator end plate (20) by tapping lightly with a wooden mallet; feed the brush leads (10) and (11) through from the carcass aperture.

Withdraw the armature (8) complete with end frame (9) and ball-bearing (12) by lightly tapping the tail shaft with a wooden mallet.

The driven end frame assembly need only be dismantled if it is necessary to replace the bearing (12).

Reassembly.—This operation is carried out in the reverse manner to that just described, but it is important to assemble the *driven end* of the armature on to the carcass first.

The Simms Voltage-regulator Unit.—This unit is shown at (17A) in Fig. 201 alongside the cut-out unit (17B). The testing and adjustment of the latter unit has already been dealt with, so that it remains only to consider the regulator unit. Fig. 247 shows a close-up view of the cut-out and regulator units as arranged in the control box fitted to heavy Leyland commercial (Diesel) vehicles.

It is important to keep the regulator contacts clean and true. The screws of these contacts are faced with soft alloy, so that only the minimum of cleaning with a fine abrasive paper should be done. After cleaning, the contact surfaces of all screws are domed to a $\frac{1}{2}$ in. radius.

The method of adjusting the regulator is as follows:

(1) Remove shorting contact adjusting screw (Fig. 247) and screw resistance contact adjusting screw forward until armature and barrel are touching.

(2) Unscrew resistance contact adjusting screw $1\frac{1}{3}$ turns and lock.

(3) Screw in shorting contact adjusting screw (Fig. 247), until all three contacts touch, then unscrew half a turn and lock. The gap between contacts will be ·016 in. Connect to dynamo and run same at 1,000 r.p.m. Regulator should be working on resistance contacts.

(4) Set voltage to approximately 29 volts by spring adjustment. This

operation should be carried out by removing the two coarse adjusting plate-fixing screws in the centre of the moulding and rotating the adjusting plate, holding the screw stationary. Replace fixing screws and finally adjust by the fine adjusting screw. Lock fine screw.

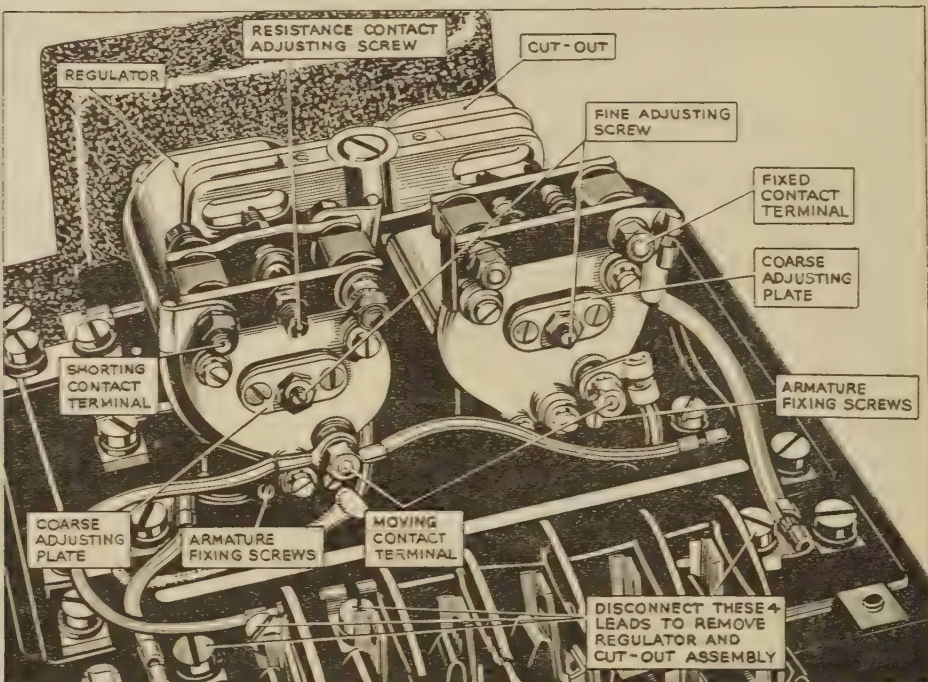


Fig. 247.—The Simms Voltage Regulator and Contact-breaker Units (Leyland).

(5) Increase dynamo speed until regulator operates on shorting contacts. If voltage rises by more than ·5 volt then magnetic gap is too large. If, however, the voltage falls or the vibrating contact flutters violently between the fixed contacts, the magnetic gap is too small. To reduce this gap screw in resistance contact adjusting screw and screw out shorting contact adjusting screw each $\frac{1}{8}$ turn.

(6) Run dynamo at 1,000 r.p.m. and reset voltage by fine adjusting screw. Repeat adjustments in (5) if necessary, i.e. until rise in voltage, when changing from resistance to shorting contact operation, is between ·3 and ·5 volt.

(7) Finally adjust to 28·5 volts on resistance contacts and 29 volts on shorting contacts by spring adjustment; lock all adjustment screws and re-check voltage.

(8) Connect a load equal to the maximum rated dynamo output across the circuit, when the voltage should fall to 25 volts.

Note.—Always shut down dynamo before adjusting regulator, or the contacts may become welded together.

C.A.V. Dynamos

These dynamos, which are widely used on commercial vehicles, are now of the two-brush type and used in conjunction with *a regulator unit* and a *cut-out* and operate either on the *compensated voltage-control system*, or upon the *current voltage-control system* previously explained. The latter charges a partially charged battery at a constant value of the charging current until a certain battery voltage has been reached, when the charging method changes to constant-voltage control. The latter method allows the charg-

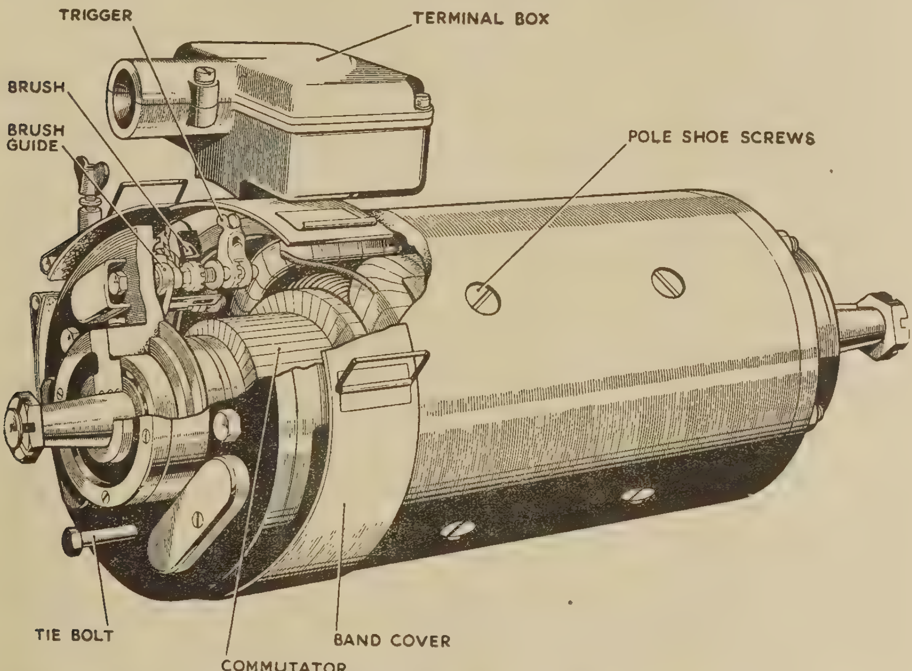


Fig. 248.—The C.A.V. Type DO7 Dynamo, in Part Cut-away View. (Courtesy of Leyland Motors Ltd.)

ing current to drop as the fully-charged state in the battery is approached until it reaches the normal trickle charge value.

Fig. 248 shows a typical C.A.V. commercial-vehicle dynamo, namely the DO7 type as used on Leyland vehicles. It is of the 24-volt 790-watt type, and gives a maximum permissible output (lamp-load) of 25 amperes. The drive ratio (dynamo to engine) is 1·4 to 1. The recommended brush-spring tension is 11 to 17 ozs.

In the present section the general maintenance and testing of the C.A.V. dynamos will be considered.

The C.A.V. dynamos are classified into *two main types* as follows: (1) For use with a regulator and cut-out mounted away from the dynamo and

(2) With the regulator or combined regulator and cut-out mounted direct on the dynamo itself.

The dynamos are made in *the plain* and *ventilated patterns*. In the case of the ventilated type the air inlets and outlets should be quite clear and away from any heat source; further, it should be protected from road dirt and water.

Maintenance of C.A.V. Dynamos.—*Armature.*—The armature can be removed after first lifting the brushes from the commutator (do not remove them from the holders, they can be held in position by wedging with the triggers), and extracting the end shield-fixing bolts in order to allow the removal of the driving-end shield.

The commutator surface should be clean and free from uneven discoloration.

There should be no deposit bridging the segments across the inter-segment insulation.

The surface can be cleaned with a very fine grade of carborundum paper except in cases where it is very pitted, when it should be skimmed up on a lathe in the manner described and illustrated later in this chapter. After truing up the commutator, mica insulation between the copper bars should be undercut, as described later; about $\frac{1}{32}$ in. (·8 mm.) undercutting is recommended for these dynamos.

Testing the Commutator Connections.—The method suggested for testing armature coils is as follows: A variable resistance, connected in series in the battery circuit, should be capable of carrying the full output of the battery and adjusted to give 2 volts or less on the armature. The latter is then rotated until every commutator bar has been tested. The reading on the millivolt-meter should read approximately the same in each case. Any big variation indicates a fault in the coil connected to one of the commutator bars under test. A reduction in the millivolt-meter reading will generally be found due to a short circuit, while an increase will indicate either an open circuit or a faulty connection.

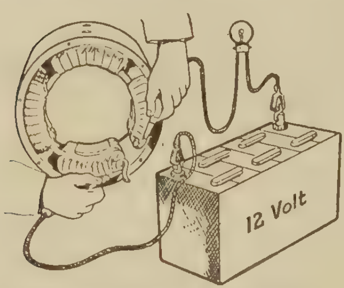


Fig. 249.—Testing the Field Coils.

Armature Continuity Test.—The method recommended for testing the C.A.V. dynamo (and starting motor) armature coils for continuity or short circuits is that of mounting the armature on a block and connecting the commutator to a car battery through the medium of two brass or copper brushes mounted at an angle of 90° to each other. Contact is then made to any two adjacent commutator bars by means of hand spikes which are connected direct to a millivolt meter. The "growler" method of testing armatures is also recommended as a satisfactory alternative.

The Field Coils.—The field coils can be simply tested without removing them from the yoke by connecting them in series with a 12-volt battery and 12-volt 36-watt bulb (Fig. 249). If the field coils are satisfactory the

bulb will light up, but its brilliance will be somewhat less than when connected directly to the battery. Failure of the bulb to light indicates an open circuit in the field-coil winding, whilst if the bulb lights with full brilliance the field coils are probably either shorted or earthed to the pole shoes or dynamo yoke. In either case new field coils must be fitted, for which is required a wheel-operated screw-driver and a pole-shoe expander in order to ensure that there will not be any air gap between the pole shoes and the inner face of the yoke. Should this equipment not be available then field-coil replacement should not be attempted.

The Brush Gear.—Inspect the brushes at regular intervals.

See that the brushes are free in their guides and that their flex leads are perfectly clear for movement.

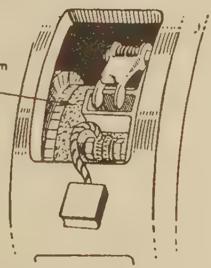


Fig. 250.—Method of Bedding the Brushes.

Where spiral fibre insulation is provided for the brush flexes, see that it has not become burnt or charred and so providing the danger of short circuits.

Positive and negative brush holders and brushes must be insulated from one another. They can be tested by means of a test lamp, as used for testing field coils and other insulation. It is not necessary to remove the brushes from their holders when testing, provided that they are all lifted from the commutator before commencing the test.

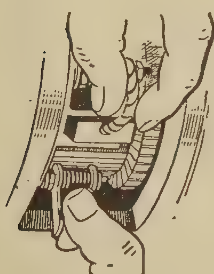


Fig. 251.—Testing the Brush for Freedom in its Guide.

If for any reason they are removed, take care to replace them in exactly the same position in the brush holder, so that the "bedding" curvature of the brush face will accurately conform to the commutator periphery. On insulated-return machines the brush gear should be insulated from the rest of the machine.

The brushes should be well "bedded," i.e. they should be worn to the commutator periphery. If not, wrap a strip of very fine glass- or carborundum paper rough side upwards firmly around the commutator, and with the brush or brushes in position rotate the armature by hand in the normal working direction of rotation until the correct brush shape is obtained (Fig. 250).

See that the brushes have not worn so that the trigger or spring is no longer providing effective pressure.

Test if the brushes are free in their guides (Fig. 251). Clean all carbon dust away with petrol and, if necessary, ease the fit. Lightly polish the sides of the brush with a smooth file.

If it be necessary to replace a brush, only the same type and grade as supplied by the manufacturers should be used.

The *pressure of the brush springs* should be tested by means of a spring

balance hooked under the spring trigger or spring tips (Fig. 252). The spring pressures vary from about 10 to 33 ozs., according to the type of dynamo. As there are at least sixteen different types of C.A.V. dynamo, the actual brush-spring pressure should be ascertained from the manufacturers.

The pressure can be varied by twisting the spring into different slot locations on tne trigger.

Dynamo Maintenance in Service.—The following are the only items which should need attention in the case of C.A.V. dynamos in actual service:

Commutator and Driving End Bearings.—When greasers are fitted they should be turned according to the maker's instructions.

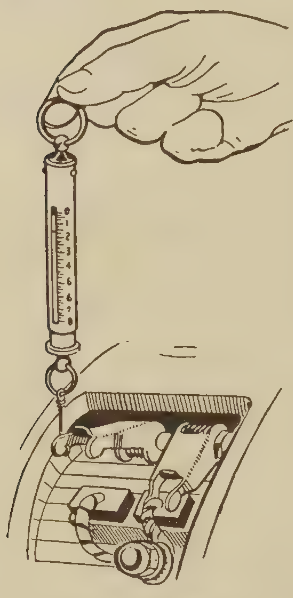


Fig. 252.—Checking Brush-spring Pressure.

A good-quality high-melting-point grease should be used. Supplies can be obtained direct from C.A.V. or any Service Depot. Dynamos without greasers only need their bearings repacking with grease at the time of complete overhaul.

If these instructions are carried out, bearings should be trouble-free with normal working. They should, however, be inspected at intervals, and replaced if showing signs of wear.

Brushes.—Inspect every 25,000 miles. If in a bad condition, or worn, they should be replaced by a genuine C.A.V. replacement to ensure the exact grade, which is important.

If face is worn irregularly, "re-bed" as previously described. Brushes should be perfectly free in the holder. Always replace the band cover over the brush-gear windows.

Commutator.—Inspect every 25,000 miles. The surface should be clean and of uniform coloration. If not, treat as described later.

Keep all parts clear of carbon dust deposited by the brushes.

Keep all terminals well tightened.

When a machine is fitted with a regulator, see that the connections from the terminals underneath the regulator platform to the brush holders are secure.

Testing the C.A.V. Dynamo.—As sent out in the new condition it can be safely assumed that the manufacturer has made all the necessary adjustments and tests in order that it may be used in conjunction with the particular set specified. If after a period of service it is desired to check performance, the following simple tests should be applied:

First remove all cables from their terminals. Connection should then be made between terminal marked F. and the main terminal, which is connected internally direct to the brush gear. This can be either marked + or — and varies according to the regulator with which it is to work. As a

rule it will be found that dynamos for use with open-type regulators must be connected between terminals F. and +, whilst those of the closed-barrel type must be connected between terminals F. and −.

Machines fitted with regulators do not have an F. terminal and care must be taken, therefore, to see that connection is made between the end of the field coil and brushes are not already directly connected.

Clip the leads of a moving-coil-type voltmeter, having a suitable range, to the two large main dynamo terminals. Run the dynamo and gradually increase its speed until a reading of 6·5 volts, 13 volts, or 27 volts is registered for 6, 12, and 24-volt dynamos respectively. Do not, however, exceed a dynamo speed of 1·300 r.p.m.

If the voltmeter remains at zero check the dynamo brush gear and internal connections. A very low reading throughout a speed rise indicates a possible faulty field winding.

General Care of the Dynamo.—Whilst the information given previously on the maintenance of C.A.V. dynamos covers most other makes, it is believed that the following summary and additional notes will be found useful to those who are called upon to service or repair various types of automobile dynamo.

The Commutator.—The only moving part of the dynamo is the armature, and from the commutator the current generated is collected by means of carbon brushes resting upon its surface. The commutator and brushes should be periodically examined, say every 5,000 miles, and to do this it will be necessary to remove the dust cover. If the commutator is a glossy bronze colour where the brushes meet the surface, it will not be necessary to do anything more than to blow or wipe away with a soft rag any carbon deposited on the brushes. To clean a dirty or neglected commutator, very fine glass-paper may be used. On no account use emery cloth.

The Brushes.—When examining the brushes, see that they slide freely in their holders to enable the springs to exert an equal pressure on them and make sure that the flexible leads are not caught in the brush gear. The surface of the brush should wear evenly to the commutator surface. Any badly worn or broken brush should be replaced by the maker's own particular spares.

It is very important that *new brushes should be " bedded " properly on to the commutator.* To do this remove the other brushes and place a piece of fine glass-paper all round the commutator, with its rough surface towards the brush to be " bedded." The commutator (and paper) is then rotated in the same direction as it normally runs when charging, until the brush surface is ground to the exact shape required.

Do not forget to replace the dust cover after inspection of brushes and commutator, and so prevent oil and dirt from entering the machine.

Lubrication.—When the dynamo is first assembled the bearings are packed with grease, which lasts for a long time. With most types, other than the oil-impregnated bronze bush ones, a lubricator will be found at either end, into which a drop or two of ordinary engine oil should be poured every 1,000 miles or so.

Bearing Removal

Should there be any signs of wear in the bearings these should be replaced by new ones.

When ball bearings are fitted the wear may occur between the inner and outer races, or there may be a flat or flats on the balls.

Special tools are available for removal of the ball-race from the armature shaft, and in this connection the vehicle manufacturers will recommend the best types.

Fig. 253 shows a typical tool, made by Crypton Equipment, Ltd., for armature ball-race removal. The armature is mounted at one end on a support. The tool is provided with a pair of jaws which are screwed down by means of the handle above so as to grip the outer ball-race. The latter

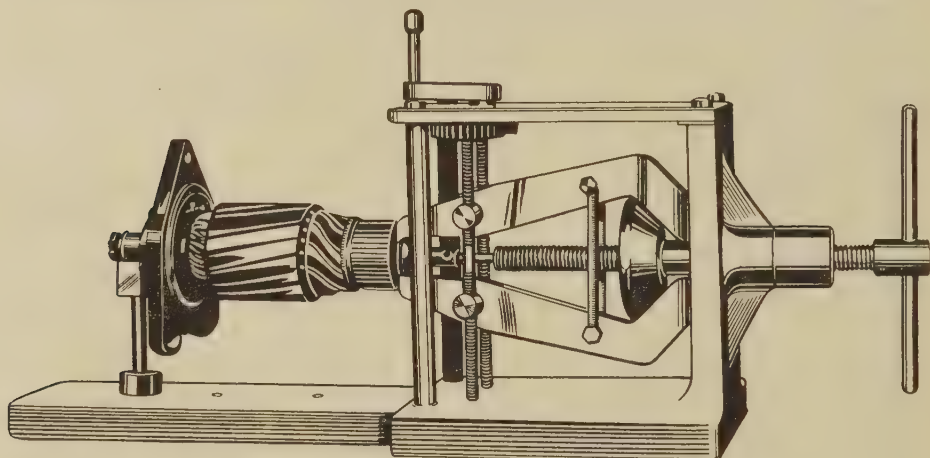


Fig. 253.—The Crypton Armature Ball-race Removing Tool.

is then pulled endwise by turning the T-handle shown on the right in Fig. 253. The harder the longitudinal pull on the bearing the more powerful the grip. The tool is designed to extract races from shafts with extensions up to 5 in., and is adjustable for all sizes of race up to $5\frac{1}{4}$ in. diameter.

There is, moreover, no tendency to bend the armature shaft when extracting the race.

In the case of plain bush, e.g. Oilite, bearings these are removed with the aid of a drift or press as explained earlier in this chapter.

Servicing the Commutator

Cleaning.—After the dynamo has been in service for some appreciable period the commutator may become worn or scored; in some cases it is merely dirty, being covered with dust from the brushes or a greasy dust deposit. In the latter case it can easily be cleaned by removing the brushes,

holding a pad of sponge-cloth dipped in petrol against the commutator whilst someone revolves it. If the rag be held on the finger, turn the engine by hand. If it is held on a shaped piece of stick, the engine can be run under its own power, slowly; a good thick pad of cloth should be used. Never use emery paper on the commutator.

Keep the commutator surface free from oil or grease; these cause sparking of the brushes, but in addition carbon and copper dust will be collected in the grooves between the commutator segments; the latter should be examined, and, if necessary, cleaned out with a thin saw blade.

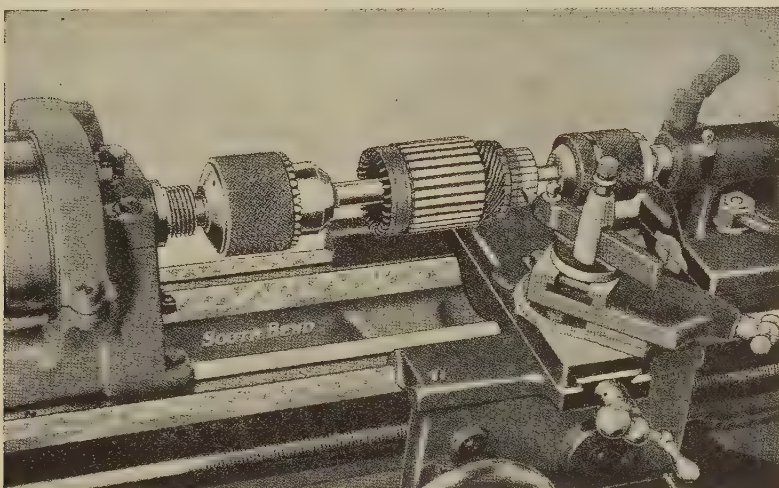


Fig. 254.—Armature Mounted in the Lathe for Truing and Undercutting Commutator.

Truing Commutator in Lathe.—The armature shaft will usually be found to have centres at either end so that it can be mounted between the lathe centres and a carrier used in conjunction with the drive pin of the face plate to rotate it. Otherwise, a self-centring or drill chuck (for smaller shafts) may be used at one end of the armature as shown in Fig. 254.[1] At the other, or free end, either a lathe centre or a steady bearing, made by inserting three brass jaws which can be adjusted to any shaft diameter, is used. A few drops of oil should be applied to this centre, or steady bearing.

When the armature shaft has centres, these must be checked for accuracy and corrected with a scraper or square centre and forcing bar, if necessary.

The recommended turning speed for car dynamo commutators is between 300 and 400 r.p.m. More generally, the surface machining speed for copper using carbon-steel tools is 100 to 150 ft. per min. For high-speed tools the speed is 250 to 350 ft. per min. and for tungsten-carbide-tipped tools, 500 to 800 ft. per min.

[1] South Bend Lathe Co.

The cutting tool used for commutators is illustrated in Fig. 255. It should have the following angles; namely, top rake, 20° to 30° for high-speed steel and 13° to 16° for tungsten-carbide tools. The front clearance should be 5° to 7°. The side cutting angle is 20° to 25° and side clearance 8°.

The ground cutting edges should be finished on an oil-stone and always kept keen. The point of the tool should be exactly level with the centre of

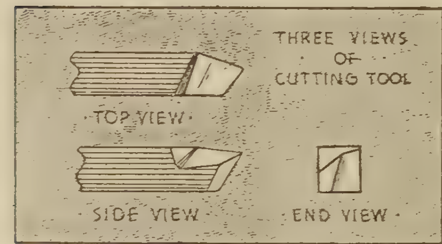


Fig. 255.—Cutting-tool Shape.

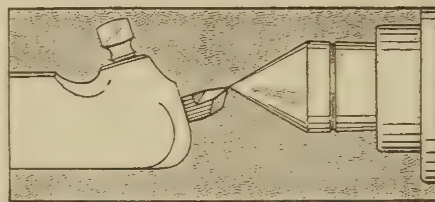


Fig. 256.—Setting Cutting Edge at Correct Height.

lathe, as shown in Fig. 256. No cutting lubricant is recommended for commutator truing.

Undercutting the Mica.—The following remarks on the undercutting of the mica insulating strips refer to the generator, the methods recommended being those of the makers of Delco-Remy electrical apparatus.

On many generator armatures the mica between the commutator bars has been undercut in the same manner as on generator armatures. The undercutting is about $\frac{1}{32}$ in. in depth. When renewing brushes on a motor with undercut commutator, it is necessary to sand-in the brushes to a good seat to prevent noisy operation and arcing. Directions for sanding-in brushes have already been given.

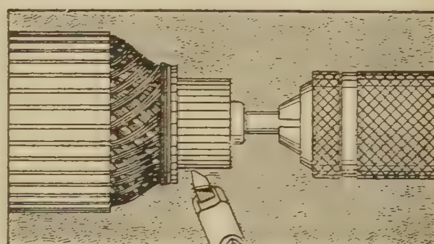


Fig. 257.—Top View, showing Angle of Cutting-tool Holder.

If an armature in service is found with a rough or burred commutator showing high mica, it should be placed in a lathe and the commutator trued up. This work should be done very carefully, as the surface of the commutator must be concentric with the armature shaft to ensure proper performance. Be sure the centres in the armature shaft are not burred or filled up before placing the armature in lathe. Drive armature at a reasonably high speed, using a fine feed and a very sharp tool.

Make sure the commutator runs true with bearing seats within ·005 in. by checking up in V-blocks.

When the commutator has been trued up, undercut the mica between

the copper bars. Cut a depth of approximately $\frac{1}{32}$ in., keeping the slot rectangular in shape and free from mica, as in Fig. 258. One of the mica undercutting machines or attachments, of which there are several on the market, can be used. In the absence of a machine, the work may be

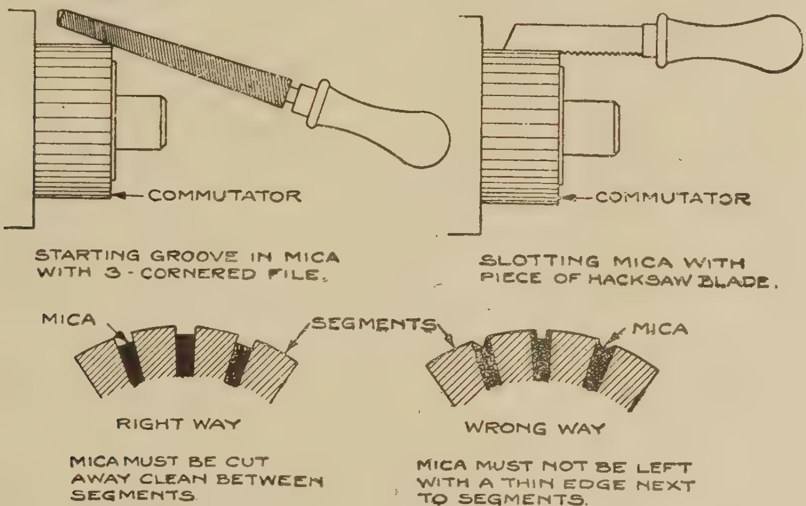


Fig. 258.—Showing how to Undercut the Mica Insulation on Commutators.

satisfactorily accomplished with a hacksaw blade, the sides of its teeth having been ground off until it will cut a slot slightly wider than the mica.

After undercutting the mica, *the edges of the slots should be bevelled* very slightly with a three-cornered file, in order to destroy any burrs which would cause excessive brush wear.

Wire hooks may be used to advantage for supporting the motor-brush arms while assembling the armature and end housing.

The Dynamo and Motor Bearings

The dynamo usually runs on ball bearings, which seldom require attention other than periodic lubrication with a few drops of engine oil (say, 6 to 8) every 500 miles. When the dynamo (or starting motor) has been in service for some considerable time, namely from 30,000 to 40,000 miles or more, the bearings should be inspected for side-play; if this exceeds ·002 in. to ·005 in., new bearings are indicated.

In some cases the driving-end bearing is an oil-impregnated bronze bush one; this needs no regular lubrication.

Typical bushes are the Oilite ones, which are self-lubricating, but it is recommended that this type of bearing should be lightly lubricated with thin oil when the dynamo is overhauled.

Some automobile dynamo and motor ball bearings are packed with

high-melting-point grease, in proper containers, by the makers, and will run for 10,000 to 15,000 miles before they require cleaning and repacking.

Testing the Dynamo for Insulation Faults

When trouble is experienced with the dynamo or starting motor, and the usual inspection has made it quite clear that this trouble is not due to mechanical defects, e.g. hot bearings, faulty carbon brushes, rough commutator surface, loose terminals, or broken external leads, it is very probable that a fault may have developed in the field or armature windings; this may be either a broken lead or a short circuit. Fig. 259 shows a useful form of stand for holding armatures for the purpose of testing them.

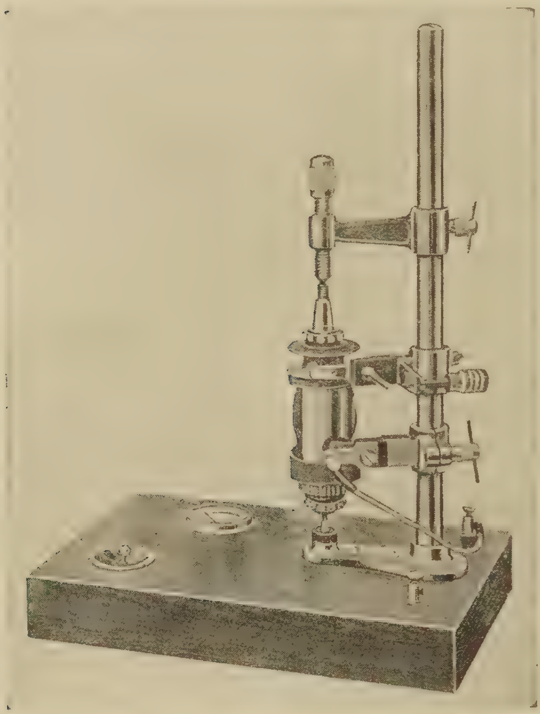


Fig. 259.—The M.E. Armature Test Stand

In most cases where the dynamo fails suddenly the fault can be traced to a break in the field-magnet wires and in order *to locate this break* each field-magnet coil should be disconnected from the rest and tested for continuity. This is a simple matter, requiring only a 4- or 6-volt accumulator, a detector galvanometer or a low-reading ammeter.

The accumulator, field-magnet coil and galvanometer or ammeter should be joined in series as shown in Fig. 260. When the connections are made in the manner illustrated, *the instrument should show a deflection.* If it does not it is evident that there is a break somewhere in the windings of the field-magnet coil.

In connection with this test the ammeter is undoubtedly the best instrument to employ, as the resistance of each coil can then be compared with that of each of the others; with a known voltage, such as the 4-volt accumulator, this resistance will be found by dividing the volts by the current reading on the ammeter.

Each field-magnet coil may give a continuity test, yet one might be short-circuited internally, a fact which the galvanometer might fail to record because its readings are mere deflections and do not signify any exact measure of the current passing; but an ammeter used as above would

show at once that the resistance of a shorted coil was unduly low, owing to the large current reading. A field coil in this condition would contribute little, if anything, to the excitation of a machine, and would need rewinding partially or wholly, using new wire if the old covering appeared at all scorched or burnt. In a shunt or compound-wound machine such defects usually show themselves by a falling off in the terminal voltage, accompanied by unusual heating up of all the field coils.

It is also desirable to test for leakage between the coil and the frame, as indicated by the dotted line AB (Fig. 260).

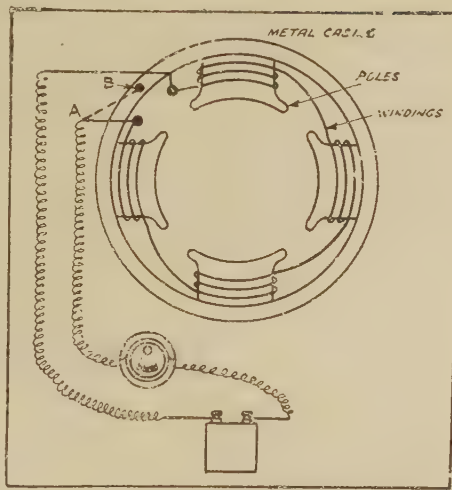


Fig. 260.—Testing the Field-magnet Coils for Faults.

Testing Commercial-vehicle Dynamo Field Coils

The method recommended for testing the field coils of 24-volt 300- to 900-watt dynamos, such as the Simms types used on Leyland and other vehicles, requires only a battery and lamp holder with bulb; the tests can be made without removing the dynamo from the vehicle. The method is as follows:

Fig. 261.—Checking the Dynamo Field Coils.

Connect the field coils in series with a 12-volt battery and 12-volt 36-watt bulb, making sure that the direction of the current flowing through the coils is the same as when the dynamo is working on the vehicle; if this is not done *the polarity will be reversed.*

If the field coils are satisfactory, the bulb will light up, but not to full brightness. The resistance of the coils is approximately 12 ohms. If the bulb does not light there is an open circuit, while if the bulb lights with full brilliance the coils are shorting (Fig. 261).

To test for earthing to the pole shoes or carcase connect one of the battery leads to a clean part of the carcase after disconnecting it from the field lead, the other left connected to the windings. If the lamp lights, then the armature is shorted (Fig. 262).

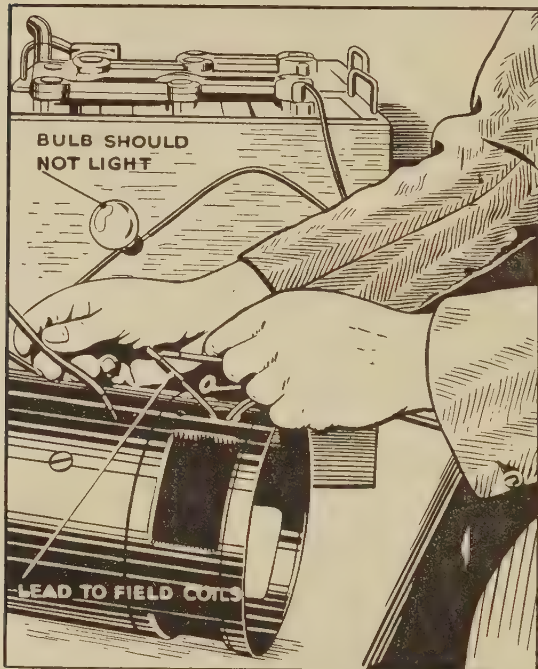


Fig. 262.—Method of Checking for Earthing of Field Coils to Pole Shoes.

Testing the Armature

The armature is a more likely source of trouble than the field coils, as its windings are less robust and of greater complexity.

Among the various faults possible in the case of the armature are those caused by vibration and movement of the coils; these include rubbing through of the insulation, leakage, and eventually short-circuiting between individual coils or between the coils and the iron core of the armature.

"Shorts" may also occur between the two ends of the same coil, or, what amounts to the same thing, between adjacent segments of the commutator. A short between coil and core can be detected by a galvanometer and cell in series, one wire being placed on the commutator and the other on the armature core or shaft (see Fig. 263). Any segment of the commutator will do, as the armature coils are all electrically continuous one with another. Shorts between the ends of the same coil, or between two commutator segments, show themselves by the fact of the coil in connection therewith burning out and the insulation on the wires becoming blackened. If several coils are shorted thus, the machine may refuse to work, and in that case it should be separately excited by passing current round the fields from some other source

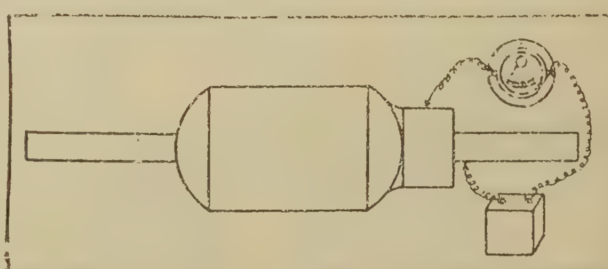


Fig. 263.—Testing Armature for a Short Circuit to Core or Shaft.

at a voltage about equal to that of the machine. On running the armature for a few moments, smoke will be seen issuing from it, and if stopped at once and carefully gone over by the hand, hot (defective) coils are, as a rule, clearly defined by being unusually hot to the touch, or blackened in appearance. To ascertain that the fault does not lie in the commutator, disconnect the coil ends from the commutator segments, and test the latter with the galvanometer. Every segment should be completely insulated from its neighbours, as well as from the frame of the machine when the armature coils are disconnected.

Passing over such obvious faults as improperly connected coils, non-inductive or opposed coils, etc., which cannot occur if winding instructions have been carried out correctly, the only other fault likely to occur is a broken armature connection, or a defective soldered joint between commutator lugs and armature conductors. This makes itself evident by severe sparking and flashing at the commutator incurable by alterations of brush position.

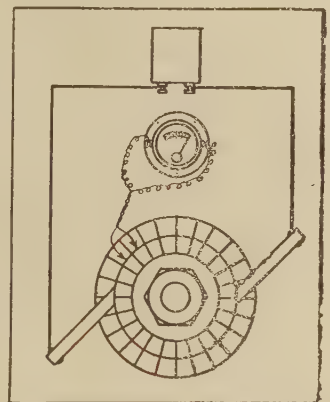


Fig. 264.—Voltage Drop Test applied to an Armature.

Voltage Drop Test.—To test for this the armature may be left in position in its bearings, the field-coil connections disconnected, and a large, steady current, as large as the armature will stand, passed through it by means of an accumulator connected to the brushes. Each coil on the armature when normal should possess a certain resistance, and when current flows through a circuit possessing resistance there is a fall of potential called the "CR drop," and by Ohm's law $C \times R = E$. This arrangement, therefore, gives a means of testing roughly the individual resistance of each coil on the armature, by the fact that there will be a potential difference E between each segment and the next in proportion to the resistance of the armature coil lying between them and being traversed by the current.

If a coil is defective, has a short circuit, for instance, there will be little or no fall of potential between the adjacent segments to which it is connected, because its resistance is too low, and the current flowing through it loses but little of its potential energy. When the coil is normal, a certain reading in volts is obtained, because this current in overcoming the resistance of the normal coil has to expend a certain amount of E.M.F., which can be read off in volts by two exploring wires from a low-reading voltmeter arranged as in Fig. 264. For the satisfactory performance of this test it is essential to use a sensitive voltmeter graded, say, in tenths or a volt to a range of 2 or 4 volts, corresponding to the voltage of the battery used for testing. The resistance of most armatures is very low, and quite a low-voltage accumulator will send a heavy current through the armature from brush to brush. In this fall-of-potential method of testing it should

be noted that when the accumulator is coupled to the armature without any extra resistance in circuit, the battery voltage must naturally correspond to the total fall of potential from brush to brush; and, therefore, counting the number of commutator segments lying between those two points, and dividing the battery voltage by such number, will give a close indication of what the voltage difference should be between adjacent commutator segments, providing all the windings are normal and without fault.

Two-pin exploring points and an ammeter, or bulb, are also employed for testing commutator insulation; consecutive segments of copper should of course be insulated from each other.

The Growler.—The armature-testing device shown in Fig. 265 is known as a " growler," and is in principle a transformer which uses the core of the armature under test to complete the magnetic circuit, the armature coils acting as the secondary winding of the transformer. The " growler " can be used for testing whether an armature has a short circuit or an earthed or open circuit. In the former case when the supply circuit is closed and an ammeter connected in series the effect of a short circuit will be to cause irregular induced voltages in the short-circuited coils, giving rise to a variable magnetic flux. If a piece of soft iron or steel strip, such as a hacksaw blade, be placed on top of the armature it will vibrate when the armature short-circuited segments are connected up. Each winding should be tested in turn, the armature being rotated in the V-block laminated core. The reading on the ammeter indicates whether there is a bad contact (low reading) or an open circuit (zero reading).

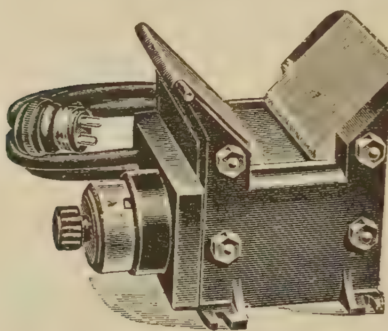


Fig. 265.—The Allen Growler for Testing Armatures for Short Circuits, etc.

Another method of testing the armature windings for earth shorts is to use either a " growler " or a test lamp and exploring points. It is necessary to know how the armature is wound, but a methodical exploration with the pair of test points will indicate whether there is an earth.

The Crypton armature testing growler,[1] shown in Fig. 266, represents an improved model of the earlier patterns of growler and it will diagnose and locate earths, open circuits, short circuits, reversed connections, incorrect coil spacing and incorrect number of turns. It can also be used for tests on dynamo and starting-motor fields and magneto armature windings. It can be operated from any standard voltage, single-phase, alternating current supply.

The equipment includes a test light with test light prods for " earth " tests, the light indicating when the growler is on. Dynamo and starter armatures can be tested by the provision of dual windings with a three-way

[1] Crypton Equipment, Ltd., Bridgwater, Somerset.

switch having series, parallel, and off positions. Incidentally, the growler may be used for drying out armatures.

Tests for short circuits are made by using the testing blade provided. When held over the armature slots (Fig. 266) parallel with the shaft, a short circuit will attract the blade towards any faulty coil.

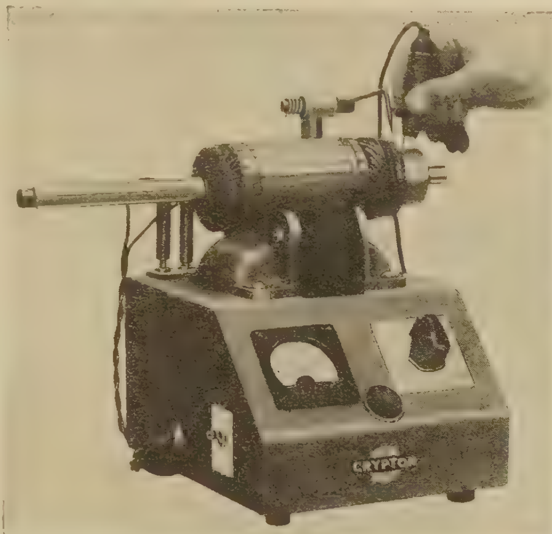


Fig. 266.—The Crypton Armature-testing Growler.

A compact and efficient armature- and coil-testing outfit, made by Messrs. V. L. Churchill Ltd., illustrated in Fig. 267, enables magneto armature windings to be checked quickly. Instead of using battery current to test the coils, this equipment utilises the current obtained in the primary by induction, and thus reproduces actual working conditions. The constant reversal of magnetic flux is retained, and armatures thus tested do not suffer from polarisation as when a battery is connected to the primary. The equipment includes, also, a three-point spark gap.

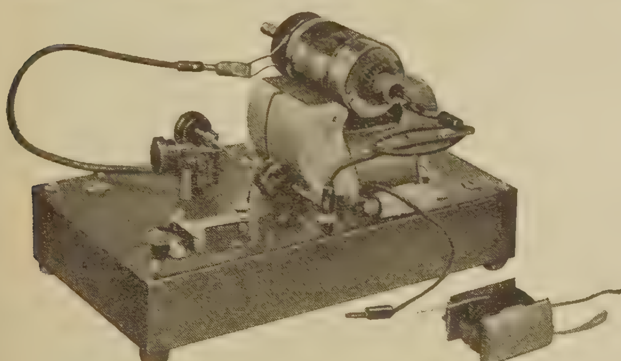


Fig. 267.—The Churchill VLC Armature and Coil Tester.

Electronic Tester for Armatures and Field Coils

Whilst the "growler" and "drop-test" methods are very useful for testing armatures and field coils, there are certain limitations to their scope; thus for field coils and other windings there has been no simple method of making quick, accurate checks for short-circuited turns.

A new method and equipment has now been developed by Runbaken, Ltd., known as the electromagnetic-echo one, which will indicate accur-

ately a single short-circuited turn in any automobile electrical equipment.

Not only is it possible to test finished products but also to check the construction whilst armatures are being built up (Fig. 268).

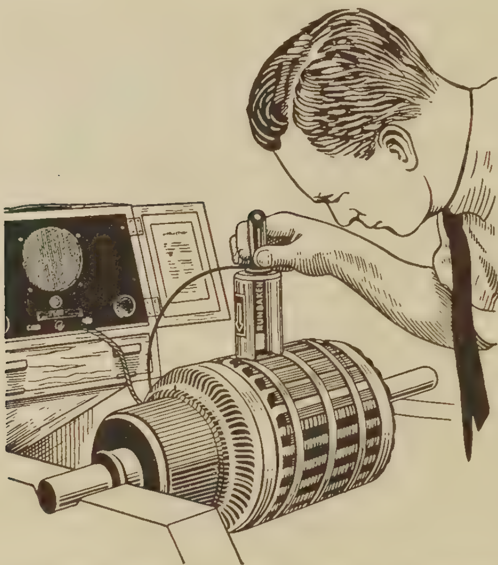


Fig. 268.—Showing the Echo Tester in Operation, Checking the Coils of an Armature.

The equipment is connected to an A.C. mains supply by means of the plugs. The tester is then switched on and time is allowed for the three valves to warm up. The signal produced by the three-valve generator is used for test purposes.

The armature under test is mounted on V-blocks, and the armature tracer head of the tester is placed with its arrow between the slots. The armature is then rotated slowly or the tracer is moved from slot to slot.

If there is a short circuit this is indicated by a loud note from the cabinet of the tester. By unsoldering connections it can be ascertained whether the "short" is in the windings or the commutator.

If there is an open circuit this can be detected by placing the tracer head on any armature slot (Fig. 269). The commutator bars connected to the leads from its slot should be traced. With a pointed metal instrument short circuit these commutator bars. If the coil is sound a loud note will be heard, whilst if there is an open circuit no signal will be heard. The operation should be repeated right round the armature until all slots have been checked.

The tester can also be employed to reveal crossed connections, flying shorts—when the armature is running at speed—stator windings, and field-coil windings. In the latter case the coil to be tested is placed on the fixed tracer column of the tester (Fig. 270). If any turns are short circuited a loud note will be heard.

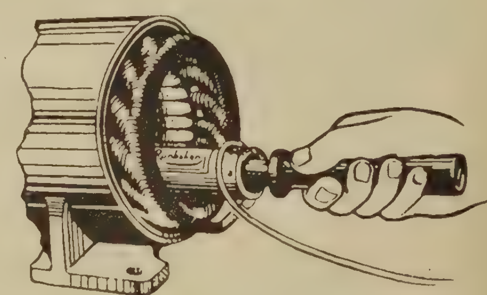


Fig. 269.—Using Stator Tester on Field Coils.

A Dynamo and Regulator Tester

A compact equipment, known as the Dynareg[1] and illustrated in Fig. 271, enables tests to be carried

[1] Crypton Equipment, Ltd., Bridgwater, Somerset.

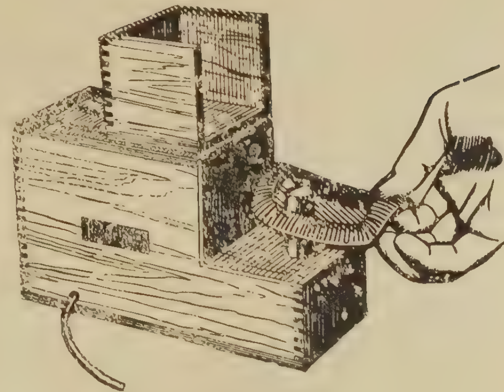


Fig. 270.—Field Coil Tester.

out in service stations and adjustments made to dynamo regulators. In addition it affords a quick means of testing dynamos, batteries, and electrical equipment.

Provision is made for testing both voltage and current regulators, cut-outs, and the entire charging circuit in automatically correct sequence. It includes an exclusive telephone dial switch which automatically selects the meter range. A special interlocked switch assembly tests the entire circuit in correct sequence. It is equally suitable as a separate multi-scale voltmeter or ammeter, for independent testing.

The complete charging circuit can be tested with only one set of test connections. Referring to Fig. 271, the rotary switch shown on the left enables six different test positions, from A to F, to be used. When rotated

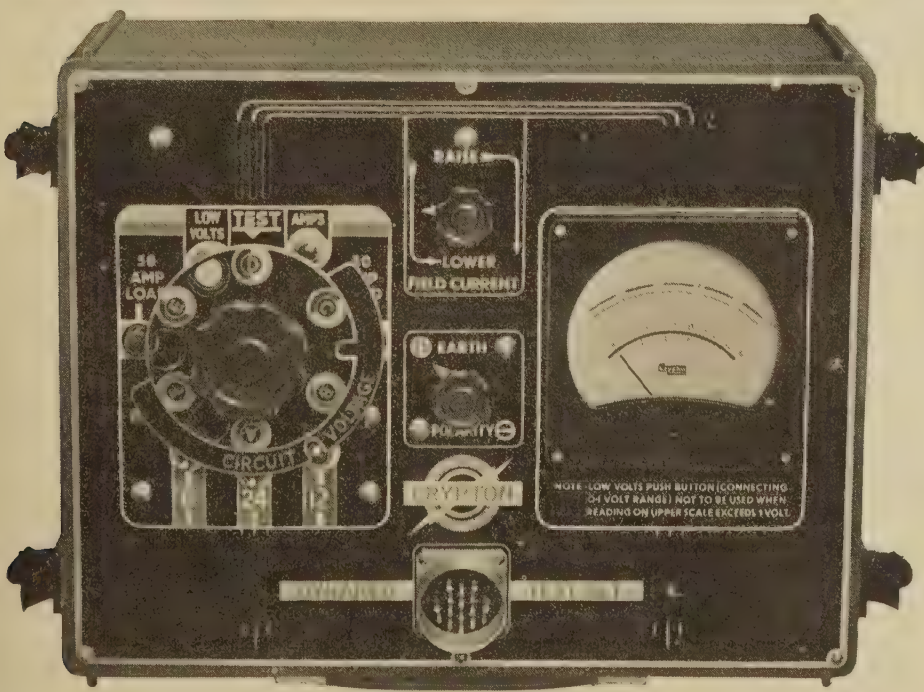


Fig. 271.—The Crypton Dynareg Testing Set.

the selector dial tests the charging circuit in the correct sequence. To the left of the selector dial is a battery-loading resistance of 50 amperes carrying capacity, which enables batteries to be tested under discharge load conditions. There is also a rotary sector dial which interlocks the instrument for 6-, 12-, or 24-volt systems. A rotary field rheostat is provided for dynamo voltages to be controlled independently of speeds.

Another useful feature is the change-over polarity switch which automatically connects the tester for positive or negative earth-return systems.

The instrument on the right in Fig. 271 has three scales for reading, respectively, 0 – 50 volts in three stages, 5–0–50 amperes for current tests and 0–1,000 millivolts for low-voltage tests.

It is not possible here to give a detailed account of the manner in which the various electrical-system tests are carried out with the Dynareg, but the manufacturers issue complete instructions.

Tracing Dynamo Troubles

Although the testing and repair of automobile dynamos is essentially the work of the skilled electrician, there is a number of points concerning the location of dynamo troubles that the ordinary motor mechanic should be familiar with and should be able to recognise.

The usual dynamo troubles may be diagnosed briefly and classified as follows:

(A) *Brush Troubles.*—These have been explained in some detail before. The symptoms are excessive sparking at the brushes, and reduced charging rate.

Brush troubles include: *Brushes Worn Too Short*, *Brushes Glazed*, *Brushes Sticking in Holders*, *Incorrect Material*, *Wrong Spring Pressure*.

(B) *Commutator Troubles.*—These include: *High Mica Insulation*, *Dirt on Commutator*, *Scoring of Commutator*, *Commutator Not True with its Shaft*. The usual symptom is that of unsatisfactory charging at low speeds, or at all speeds.

(C) *Faults in Windings.*—These faults may occur in the armature or field circuits. If the dynamo fails to charge at all this may be due to one or other of the following causes: *Open Field Circuit*, *Open Armature Circuit*, *Earthed or Short-circuited Armature Circuit*, *Short Circuit in Field Coil*, *Open Circuit between Dynamo and Battery*.

(D) *Brushes, Adjustment.*—If the main brushes are not properly at their advance positions and the third brush when this type of dynamo is used is incorrectly set, the dynamo will not charge satisfactorily.

Dynamo Failure to Charge

The complete failure of the dynamo to charge has been dealt with (in part) in C above. Among the other possible causes of this trouble are: *Field Terminals Wrongly Connected*, *Third Brush or Regulator Incorrectly Adjusted*,

Dynamo Terminals Earthed, *Dynamo Cut-in Not Operating* (this can be tested by manually closing the armature of contact), *Drive Disconnected* (if a belt drive is employed, this may be slipping).

Sometimes a *Defective Ammeter* may lead one to imagine that the dynamo is not charging properly. Always test with a spare laboratory-type ammeter.

The ordinary dashboard ammeter is not a reliable instrument, and one should not place too much confidence in its actual readings, but should rather tend to regard it as an indicator of the correct dynamo functioning, than as a measure of the output.

Dynamo Output Low

The following are the possible causes of a low charging current in the case of the dynamo: *Incorrect Third-brush Adjustment*; *Damaged Windings*; *Commutator Mica Too High*; *Dirty Commutator*; *Brushes Glazed, Too Short, Dirty, Sticking in Holders or Not Bedding Properly*; *Damaged Battery*; *Open in Charging Circuit.*

FAULT-FINDING TABLE FOR DYNAMO

DYNAMO NOT CHARGING.			— Broken or loose connections. — Charging switch off. — Switchbox fuse blown.
CHARGING INTERMITTENTLY OR LOW OUTPUT.	— DYNAMO.		— Belt slipping. — Loose terminal nuts.
		— BRUSHES.	— Greasy or dirty. — Worn. — Tight in holders. — No spring tension. — Shunt-brush position altered.
		— COMMUTATOR.	— Greasy or dirty. — Worn or rough. — Copper dust between segments.
	— SWITCHBOX.		Loose fuse or connections.
	— BATTERY.		Broken or loose connections.
CHARGING WITH EXCESSIVE OUTPUT.	— SHUNT CIRCUIT.		— Brush position altered. — Brush not "bedding."

A Dynamo Precaution

It is very important to short-circuit the dynamo by connecting the dynamo terminal to the relay mounting screw if for any reason the engine is to be *operated with the battery removed or disconnected.*

Ammeter Readings and their Interpretation

The ammeter should read zero when engine is not running and all lights, etc., are turned off. Ammeter reading other than zero with above conditions indicates:

1st. Ammeter reading incorrect.

2nd. Short or earth in car wiring or switch.

The ammeter will read " discharge " at low engine speeds, but should read " charge " whenever the car is driven at more than 11 m.p.h. with lights, etc., turned off.

When all lights are on, it will require a speed of approximately 15 m.p.h. to show charge. At a lower speed than this the ammeter will show discharge, which means that more current is taken by the lights and ignition than is furnished by the dynamo.

If the ammeter fails to show charge, look for:

(1) Damaged or " shorted-out " ammeter.

(2) Dynamo trouble.

(3) Relay trouble.

(4) Open between dynamo and ammeter.

If, at any time, the ammeter shows a discharge in excess of 15 amperes, look for a short in car wiring or equipment.

(1) Battery terminals reversed.

See that negative terminal of battery is connected to frame side member of the car.

(2) Ammeter connections reversed.

CHAPTER 8

THE STARTING MOTOR

Automobile starting motors are usually of the *Series-wound* type, in which the field-coil windings are in series with the armature winding. This arrangement gives the maximum starting torque, for there is very little resistance at zero or very low speeds. The starting motor is connected direct to the battery, a switch being interposed.

The usual wiring diagram of the automobile starting motor is an entirely separate circuit, and there are no connections with the switchboard, lighting, or dynamo circuits. The starting switch may, of course, be on the switchboard, but its wires are separate from the other circuits.

Fig. 272A shows the wiring diagram of a single-pole starting-motor circuit. In this case the positive terminal of the battery is earthed and the negative connected through the starting switch to the one pole of the motor; the other pole is earthed to frame.

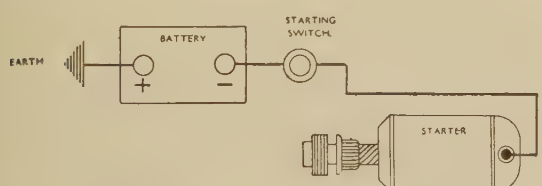


Fig. 272A.—Starting-motor Wiring Method.

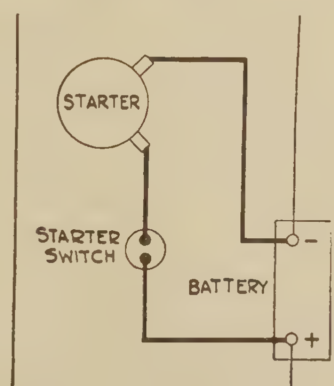


Fig. 272B.—Starting-motor Circuit (Double Pole).

Fig. 272B illustrates the wiring diagram of a starting motor of the two-wire or "pole" system. In this case both positive and negative terminals and leads are insulated from the frame. The fine lines from the positive and negative battery terminals indicate the leads to the switchboard for the dynamo and lighting circuits.

The type shown in Fig. 273 is known as the "*Inboard*," and is one in which the pinion moves inwards towards the motor to engage the flywheel teeth; in the case of the "*Outward*" type, it moves outwards (Fig. 274). A

bearing is arranged at the end of the shaft, in this case to prevent the shaft bending.

The exact method of operation of the gear is easy to follow. If the shaft were standing still and the pinion were rotated it would travel along the sleeve and would engage with the flywheel. An exactly similar proceeding takes place when the pinion is at rest and the spindle is put in motion by operating the starter switch. When this is done, the pinion is drawn along the sleeve and engages with the gear ring on the flywheel; as soon as it is fully meshed it rotates the engine. When the engine fires it over-runs the motor and automatically thrusts the pinion out of engagement.

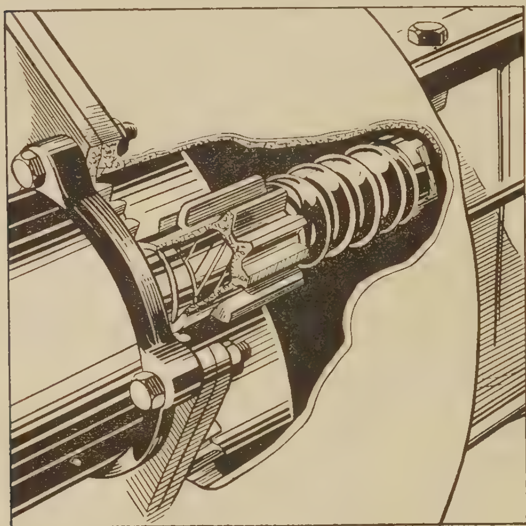


Fig. 273.—Inboard-type Starting Motor.

Starting-motor Characteristics and Data

Two principal types of starting motor are employed for motor vehicles, namely the four-pole four-brush series one having two field windings, as shown in Fig. 275, and the four-pole four-brush series with four field windings (Fig. 276). The former type is used for small cars and the latter for cars and commercial vehicles.

Fig. 274.—The Outboard Type of Bendix Pinion Drive.

Referring to Fig. 275, as the starting current is much lower than for the larger starting motors, a switch—sometimes of the pedal-operated type—can be used in the supply line from the battery to starter.

In the instance of larger motors, w here heavy currents flow through the main starting circuit, a solenoid switch is fitted on the motor casing, as shown in Fig. 276. This is energised by current from the ordinary supply, so that only a low value of current is required and a simple dashboard press-button switch can be used for starting purposes.

The effort or torque required to rotate the engine is much greater with

the engine initially at rest; it is known as the *breakaway torque.* Once started, a much lower torque is required; usually about twice as much torque is needed for starting than for turning at the usual low cranking speed (60 to 90 r.p.m.).

The starting motor must be capable of providing the breakaway torque, and in this connection the starting-motor torque is known as the *locked torque.* The torque needed to rotate the engine after starting from rest is known as the *driving torque.*

From tests made to determine the effort required to start various types of petrol and high speed oil engines from the cold under various temperature and oil viscosity conditions, the corresponding starting torques have been estimated, and the electrical manufacturers have provided a range of starting motors to cover all existing engines.

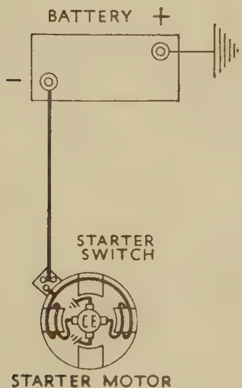


Fig. 275.—Starting Motor with Two Field Windings.

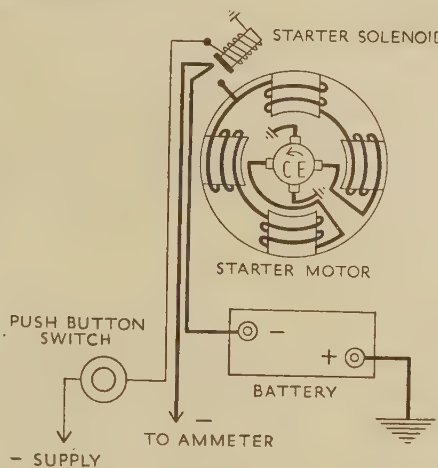


Fig. 276.—Starting Motor with Four Field Windings.

The usual range of starting or locked torques is from about 30 to 100 lb.-ft. for motor-cars and commercial vehicles.

It may here be mentioned that the series-wound motor has the desirable property of giving its greatest torque when starting from rest, the torque thereafter diminishing with increased engine speed. A typical starting motor operating from a 12-volt battery would develop a maximum of 1·3 b.h.p. at about 1,500 r.p.m. and have a starting (locked) torque of 73 to 77 lb.-ft., falling to about 50 lb.-ft. at 500 r.p.m. The starting current would be about 450 amperes, falling to about 300 amperes at 500 r.p.m.

It should be noted that the speeds given are the actual motor armature ones. Since the motor is geared down to the engine flywheel starter ring —usually in the ratio of 1 : 10—the engine speeds corresponding to 500 r.p.m. will be 50 r.p.m.

In the case of Diesel-engine starting motors, these require to be more

powerful than for petrol engines of the same output. The cranking speeds to start the average commercial-vehicle Diesel engine are appreciably higher than for the petrol engine; the usual starting speeds are from 90 to 180 r.p.m.

Starter motors of 4 to 6 b.h.p. are fitted to such engines, and in these the starting currents range from about 600 to 1,000 amperes, falling to about 500 to 600 amperes when the motor is exerting its driving torque at 100 to 150 r.p.m. (engine speed).

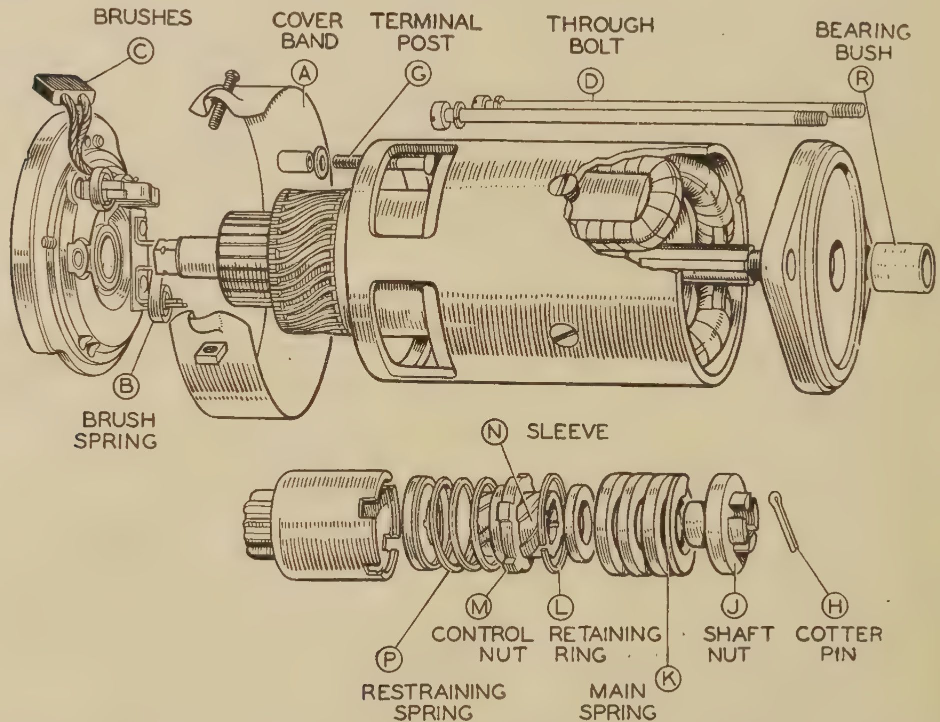


Fig. 277.—The Lucas Type M35G Starting Motor, in Partly Dismantled View

Typical Car Starting Motor

A modern car starting motor of the type suitable for cars rated at 12 to 16 h.p. is illustrated in partly dismantled view in Fig. 277. It is fitted with the Bendix pinion or quick-start threaded-sleeve pinion device. The armature shaft runs in oil-impregnated porous bronze bushes which require no separate lubrication attention.

The starting motor is provided with a flanged end for bolting to the engine casing, so that the pinion will engage the flywheel rim teeth accurately.

Removal of Starting Motor.—To remove this type of motor, first disconnect the battery earth lead—as a precautionary measure—and then

take off the starter cable from the starter terminal and unscrew the two casing flange bolts that secure the starter to engine casing, when the starter can be lifted out. In the pattern of starting motor fitted to Morris Oxford Six and other cars the *rear bearing* of the starter shaft is *located in the engine casing*, so care must be exercised when replacing the starter to engage the shaft end in this bearing correctly.

Testing the Starting Motor on Vehicle

The procedure for testing the starter in position on cars, e.g. the Austin A40 and Morris cars, is as follows:

First ascertain that the battery is in the charged condition.

Then switch on the lamps and operate the starter control. If the lights go dim but the starter is not heard to operate, an indication is given that current is flowing through the starter but that the starter pinion is meshed permanently with the geared ring on the flywheel. This has probably been caused by the starter being operated while the engine is still moving. In this case the starter must be removed from the engine for examination.

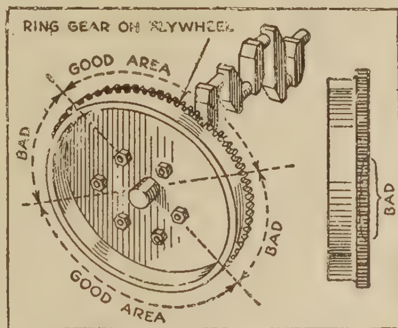


Fig. 278.—Showing how the Life of the Starter Ring on Flywheel may be prolonged.

Should the lamps retain their full brilliance when the starter switch is operated, check that the switch is working correctly. Then examine the connections at the battery and starter switch. If after this the starter fails to operate, it is probably due to some fault in the starter itself, and it should be dismantled for inspection and test. If the motor operates slowly with a well-charged battery, this is an indication that there is a poor connection or defective brush gear.

Failure to Mesh with Flywheel

If on operating the starter switch the motor speeds up without its pinion engaging the flywheel ring, this indicates *dirt or thick greasy deposit* between the starter thread and pinion, creating too much resistance to the pinion's movement. The pinion and sleeve should be washed with paraffin, working the pinion axially by hand.

If *the flywheel ring teeth are badly worn* the pinion will not engage properly. The remedy is a new starter ring or, when possible, to remove the ring from the flywheel and fit it in another position, for the flywheel usually comes to rest in one particular region when the engine is switched off. Sometimes the complete flywheel can be unbolted from the crankshaft flange and turned through a given angle, when the bolt holes will again coincide, so that the flywheel can be bolted up in another angular position.

Overhauling the Starting Motor

As the starter is used intermittently and for short intervals only, it has a relatively long life before overhaul becomes necessary. It is, however, advisable after the car has done from 30,000 to 40,000 miles to inspect the commutator and brush gear. The starter should be removed from the engine for this purpose.

At the same time the bearings should be examined for end and radial wear.

To dismantle the starter, take off the cover band A (Fig. 277) and hold back the brush springs B from their holders. Remove the terminal nuts and washers from the terminal post G on the commutator end bracket.

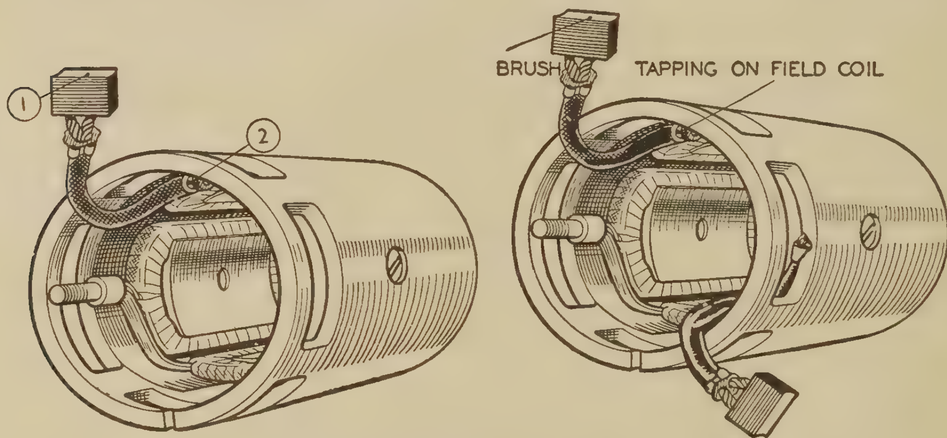


Fig. 279.—Typical Motor Brush Connections.
(Left) The Brush to Field Coil Connection of M356 Motor (Lucas) as used on Austin Cars. (1) Brush. (2) Field Coil. (Right) Lucas starter correction on Morris Cars.

Unscrew and take out the through-bolts D, and take off the commutator end bracket.

Remove the driving end bracket, complete with the armature and starter yoke.

Dismantling the Starter Drive.—If it is found that parts of the drive are worn or damaged they must be replaced. The drive is dismantled by first removing the cotter pin H from the nut J at the end of shaft (Fig. 277, lower diagram).

Unscrew the nut (right-hand thread) and take off the main spring.

The complete drive can now be removed from the splined shaft by pulling it off with a rotary movement. Unscrew the screwed sleeve from the barrel assembly.

Further dismantling of the barrel assembly is carried out by removing the large retaining ring L.

Note.—If the screwed sleeve is worn or damaged it is essential that it is replaced, together with the control nut.

Reassemble by reversing the above procedure.

The Brush Gear.—After dismantling the starter motor examine the brushes and see that they move freely in their holders, by holding back the brush springs and then gently pulling the brushes by means of their flexible connections. A sticking brush can be freed by removing it and cleaning its sides and those of the holder with petrol.

If the brushes are examined it will be observed that one is connected to the commutator end bracket, as shown at C in Fig. 277, and another to the end of the field coil winding (Fig. 279).

Worn brushes should be replaced after unsoldering the flexible lead connectors. The replacement brushes on Lucas motors are pre-formed so that they do not need bedding in.

The Commutator.—This should be examined for signs of blackening or wear, and if necessary cleaned with a cloth moistened with petrol. If in bad condition it should be polished with fine glass paper, or if scored trued in the lathe in the manner described for dynamo commutators.

After truing a starter-motor commutator, the mica insulation between the copper segments *must not be undercut*; this, it will be noted, is a different procedure from that for dynamo commutators.

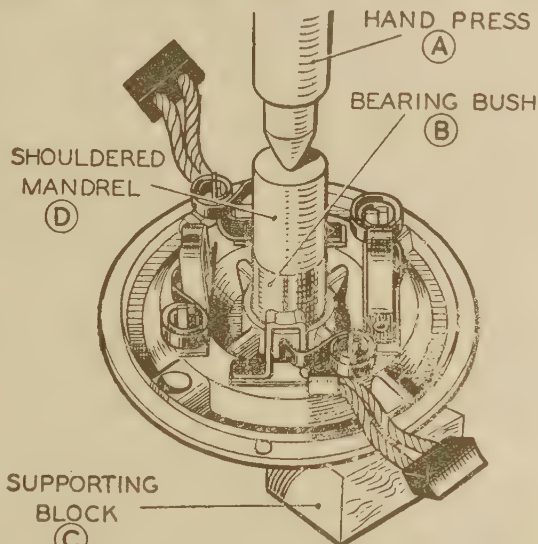


Fig. 280.—Fitting a New Brush in the Starting Motor End Cover (Morris).

Renewing Commutator End Bearing.—If the bearings, after cleaning both the shaft journals and the interior surfaces of the bearing bushes, show excessive side play, they should be replaced by new ones. The procedure for the oil-impregnated bushes used on Lucas starting motors is to press out the worn bush, using a stepped punch or mandrel held in a hand press. The new brush is inserted in a somewhat similar manner (Fig. 280); the smaller diameter of the short shouldered mandrel should be a free fit in the bush hole, and the larger diameter slightly less than the outside diameter of the bush.

New porous bronze bearings should be immersed in clean engine oil for about a day before fitting into the starter motor.

Cables for Starting Motors

In view of the heavy starting current that has to be taken by the starting-motor circuit, the cables from the battery to the starting switch, the latter

to the motor input terminal and from the battery to the earth connection must be of ample conductor section.

Usually these cables consist of 37 or 61 separate tinned wire strands of 18 to 20 S.W.G. enclosed in vulcanised rubber casings enclosed in varnished cambric and an outer braided weatherproof covering.

Notes on Starting-motor Maintenance

The starting motor is one of the most reliable items of the car, and if carefully used seldom gives trouble. With the self-oiling types no attention is necessary over long periods. In the case of the ordinary ball-bearing types, it is necessary to fill the armature shaft oilers about once every 1,000 miles or so.

Failure of the Bendix drive pinion to engage the flywheel gear, in cold weather, indicates the presence of gummy dirt on the square threads of the Bendix drive; this should be cleaned off in the following manner:

Press the starter button and release quickly. Repeat until the Bendix pinion is fully meshed with the flywheel gear. With a paint brush dipped in paraffin, brush the screw threads back of the pinion, rotating same slightly. *Very little paraffin should be used. Never use petrol*, because it removes all lubrication.

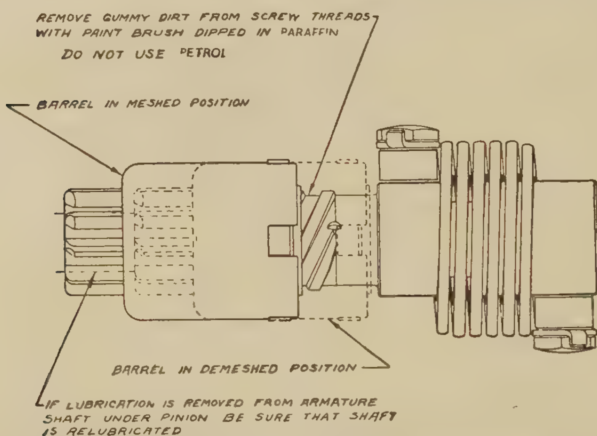


Fig. 281.—Illustrating the Maintenance of Bendix Pinion.

Start the engine several times in order to work the paraffin into the gum on the screw threads of the Bendix drive. It is desirable to remove any excess paraffin, after cleaning, by brushing with a dry brush or wiping with a clean cloth.

While the Bendix drive can be cleaned without removing the starter, it is recommended that the starter be removed before cold weather each year and the screw threads cleaned according to the above instructions.

Never wash the whole Bendix drive in paraffin or petrol. Clean only the screw threads. In case the lubrication is cleaned off of the armature shaft under the pinion, it should be re-lubricated.

As in the case of the dynamo, *the brushes and commutator* must be kept clean and free from oil, brush dust, etc. The mica insulation must be kept below the surface of the copper segments by the method previously described in detail.

Cold-weather Starting

The starter is designed to operate, or start, the engine in normal circumstances, namely, in mild weather with the carburettor, ignition, and valves functioning properly. It is sometimes too much to ask a motor to start an engine from the cold, in cold weather, without some assistance on the driver's part. It is therefore advisable to lessen the task of the motor, by first giving the engine a few swings around by hand, with the carburettor flooded and ignition switched off. The starting motor will then find it easier to do its designed work.

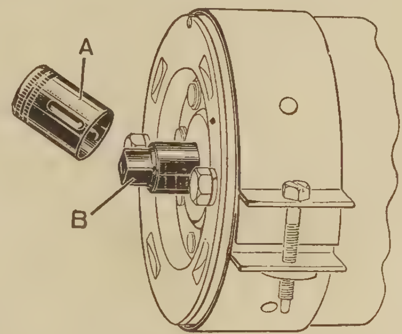


Fig. 282.—Squared End of Lucas Starting-motor Shaft with Cover removed.
A, Metal Cover.
B, Squared End of Shaft.

Constant abuse of the starting motor in cold weather will soon run down the battery.

Also, be sure that the ignition switch is really "on" before depressing the starter switch; it is only necessary to keep the latter depressed sufficiently long enough for the engine to fire; it should then be at once released.

If the engine does not fire at once, make certain that it is correctly adjusted; test the ignition and carburettor for faults; do not continue to crank the engine with the starter, as this will quickly run down the battery.

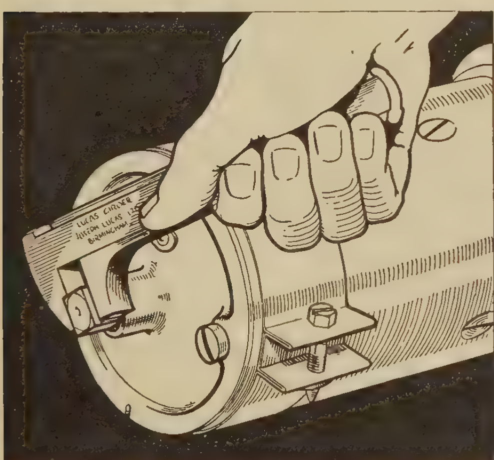


Fig. 283.—Releasing Jammed Starting Motor.

Care of the Lucas Starting Motor

The starting motor requires practically the same care and attention as the dynamo, as regards the starter-brush gear and the commutator.

If, for any reason, the pinion wheel on the motor does not engage with the flywheel teeth, examine the screwed sleeve on the armature spindle to see that it is free from dirt; if necessary, wash over with paraffin. Occasionally give it a few drops of machine oil.

Most starters are provided with extended shafts with square ends, which can be rotated by means of a spanner in the remote possibility of the pinion becoming jammed in mesh with the flywheel for any reason. Access is

obtained to the squared end by pulling off the metal cap A (Fig. 282). If it is a tight fit, lever it off with a screw-driver.

The following points should be observed when starting the engine:

(i) Always retard the ignition when a control is fitted. This minimises the possibility of back-firing.

(ii) Operate the starter switch firmly without hesitation.

(iii) Never operate the starter when the engine is running. If the engine does not fire at once, allow it to come to rest before pressing the switch again.

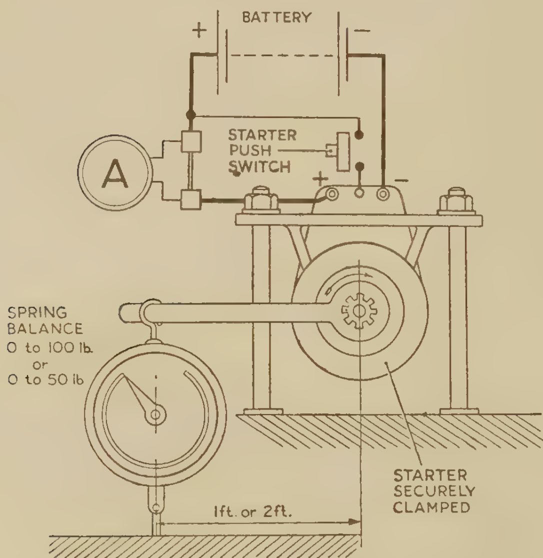


Fig. 284.—Making a Lock Torque Test (Leyland).

(iv) In cold weather give the engine about half a dozen complete revolutions with the ignition switched off and the starting handle engaged. Set the throttle and choke of the carburettor to their correct starting positions beforehand. Then switch on and use the starting motor.

(v) Never race the engine at first, but allow a few minutes for it to warm up and to allow the lubricating oil to circulate.

The Lock Torque Test

The lock or stall torque, as mentioned earlier, is the torque required to start the engine from rest. Most starter-motor manufacturers give information on the values of the lock torques of their motors, so that the latter can be checked after overhaul or should any loss of power occur in service.

The method of making the lock torque test is illustrated in Fig. 284 in the case of the Simms axial starter fitted to certain Leyland heavy-vehicle engines.

The starter motor is mounted with its casing fixed securely to a suitable bracket, and is wired up to the battery, solenoid, and push switches as indicated in Fig. 284. An ammeter reading up to 1,500 amperes is connected in shunt as shown. A flat plate should be fitted over the plunger cover screws so that *the pinion is held in the engaged position.*

Arrange a steel arm to engage the pinion teeth at one end, and a spring balance at 1 ft. or 2 ft., as the case may be, from the centre of the pinion. The spring balance must read up to 50 lb. for the 2-ft. arm or 100 lb. if used with the 1-ft. arm. When the push is operated, the current should rise rapidly to a peak figure which, together with the corresponding spring balance reading, should be noted. With a 24-volt 180 ampere-hour battery, the readings should be 90 lb.-ft. and 1,200 amperes.

Delco-Remy Starter Motors

Various types of starting or "cranking" motors are made by Messrs. Delco-Remy, Ltd., and are employed on many American and certain British vehicles, e.g. Albion, Leyland, Tilling-Stevens.

The simplest motor has a foot-operated switch mounted on the floorboard or on the motor itself, as shown in Fig. 285.

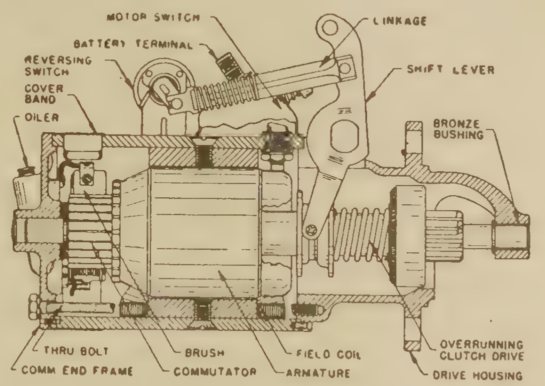


Fig. 285.—Delco-Remy Starting Motor, with Over-running Clutch Drive and Reversing Switch.

Some starting motors employ a Bendix drive with a magnetic switch, a small electro-magnet, which when energised draws in a plunger and causes a contact disc to make contact between two terminals to complete the circuit from the battery to the cranking motor. The magnetic-switch winding may be energised in a number of ways, e.g. by a dash push-button; a vacuum switch; the ignition switch—or a combination of these. Some applications with over-running clutch type of drive use a somewhat larger magnetic switch, known as a *solenoid switch*, wherein the plunger not only thrusts against a contact disc to close the battery circuit, but the plunger is also linked to an over-running clutch shift lever so that the clutch pinion is moved into mesh with the flywheel teeth by the solenoid action. The solenoid may be controlled in various ways, e.g. dash push-button; ignition switch; solenoid relay; vacuum switch or combinations of these. Fig. 286 illustrates the Bendix-drive starting motor with magnetic switch and control circuit.

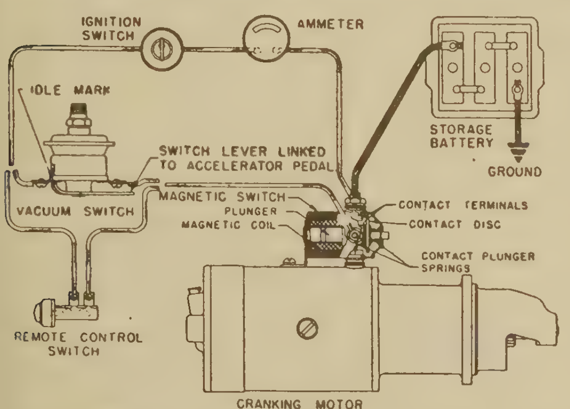


Fig. 286.—Bendix-drive Starting Motor with Magnetic Switch and Control Circuit.

Over-running Clutch Drive.—The operation of this type of drive is the same, regardless of whether the motor is actuated by a manual switch and shift or movement (Fig. 285) or by a solenoid switch and movement (Fig. 288). In either case the shift lever moves the clutch assembly on the splined

section of the armature shaft, moving the pinion into mesh with the flywheel teeth. As the shift lever reaches the limit of its travel, it closes the cranking-motor switch contacts. Occasionally, instead of meshing, the pinion teeth and flywheel teeth butt. When this happens, the clutch spring compresses and when the switch contacts close the starting motor turns only enough to align the teeth before full meshing takes place and cranking is completed. After the engine begins to operate and before the pinion can be withdrawn from the flywheel teeth the over-running clutch permits the pinion to over-run the motor armature, thus preventing the armature from rotating at excessive speed. The over-running clutch consists of a pinion and collar assembly, an outer shell with four rollers which tighten between the pinion collar and shell so that the cranking torque is transmitted, but loosen to permit the pinion to over-run the shell when the torque is in the opposite direction.

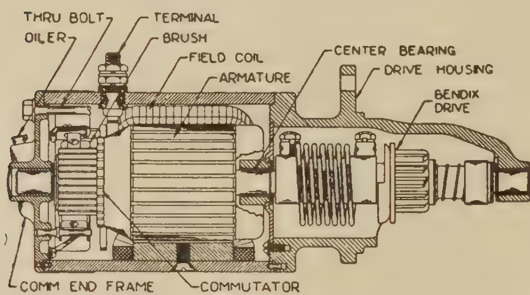


Fig. 287.—Bendix-drive Starting Motor.

Maintenance of Delco-Remy Starting Motors

Efficient operation and freedom from failures can be avoided in these and, indeed, all other types of starting motors, by a few simple checks carried out at regular intervals. In the following maintenance notes the intervals given are based on average regular operating conditions.

One Month or 1,000 Miles.—Visually check connections and cables between cranking motor and battery. Check mounting bolts.

Lubrication and inspection.—Add a few drops of light engine oil to the hinge-cap oiler. On the type of motor with grease cups, turn the grease cup down one turn, make sure the cup is filled with medium cup grease.

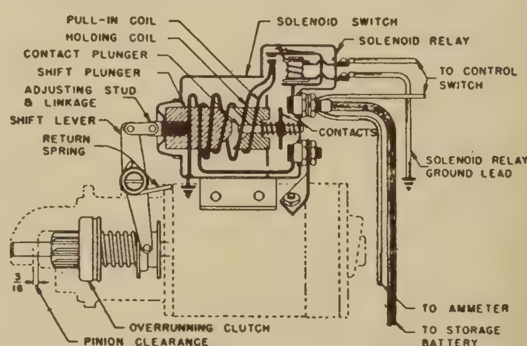


Fig. 288.—Over-running Clutch-drive Starting Motor, with Solenoid Switch and Relay.

Six Months or 6,000 Miles.—Remove the cover band and inspect the commutator and brushes. If the commutator is dirty, it may be cleaned with

a strip of No. 00 sand-paper held against it with a piece of soft wood while the cranking motor is operated with the ignition switch off. *Never use emery cloth* since emery will embed in the commutator and cause rapid brush wear. Blow out dust. If the commutator is rough, out of round, or has high mica, it should be turned down in a lathe and the mica undercut. Replace worn brushes. If the brushes wear rapidly, it may be advisable to remove the cranking motor and check for excessive brush-spring tension and roughness or high mica on the commutator.

Seasonal Attention.—Remove the cranking motor, disassemble it so all parts may be cleaned and worn parts replaced. Never clean the armature or fields in any degreasing tank since this would damage the insulation. Check the brush holders to make sure they are free on their pivots and have the proper spring tension. The commutator may be trued in a lathe if necessary. Bearings, after cleaning, may be re-packed with the proper grease. The gear housing on the gear-reduction-type unit may be repacked with graphite grease. On the type unit with oil wicks, the wicks should be saturated with oil before reassembly. Put a few drops of light engine oil on the oil-less type bushing. Avoid excessive oiling.

The Bendix drive should be well cleaned and lubricated by the addition of a small amount of light engine oil. Avoid over-oiling since this might cause the pinion to stick. If the pinion teeth are burred, replace the pinion with a new one.

Check the drift-pin spring since the pinion might tend to drift into mesh with the flywheel teeth while the engine is running if the spring is weak.

The over-running clutch drive internal mechanism is packed with a special high-melting-point grease in initial assembly and requires no further lubrication. Do not attempt to clean the clutch by grease dissolving or high-temperature methods, since this would cause the clutch to lose its lubricant. If the pinion does not turn freely in the clutch in the over-running direction, if it tends to slip in the opposite direction, or if the pinion is excessively loose, replace the clutch.

In reassembling the cranking motor, use resin flux (never acid flux) to make soldered connections. It is desirable to submit the reassembled unit to No-load and Torque tests if such testing equipment is available, in order to make sure the unit will perform according to specifications.

Where the over-running clutch shift is solenoid operated (Fig. 288), the clearance between the pinion and the housing should be checked when the pinion is in the operating condition. This clearance should be $\frac{3}{16}$ in. and is adjusted by turning the stud in the solenoid plunger in or out as required.

Motor Not Cranking Properly.—If the cranking motor does not develop rated torque and cranks the engine slowly or not at all, some indication of the source of trouble may be gathered by turning on the lights and attempting to crank.

(1) If the lights go out as the cranking-motor switch is closed, it is prob-

able that a poor connection exists at the battery terminals or elsewhere in the circuit.

(2) If the lights dim considerably, but still burn, it is likely that the battery is run down. Or possibly there is some mechanical trouble either in the cranking motor or in the engine which makes it difficult for cranking to take place and an excessively high current drain on the battery consequently results.

(3) If the lights do not dim, it indicates there is no current flowing to the cranking motor, due either to the cranking motor or the cranking-motor switch being open.

The above checks give only an approximate idea of the source of trouble so that in an emergency it might be possible to effect a temporary repair which would bring in the vehicle. To make a systematic analysis of the cranking-motor system, the first step would be to check the battery specific gravity. Then the battery connections and cables should be checked, along with the cranking motor switch.

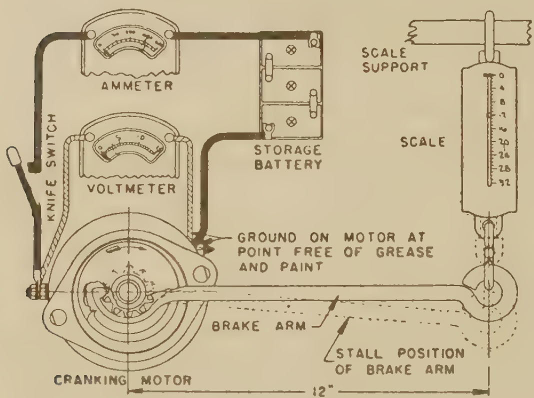


Fig. 289.—Method of making Stall Test on Starting Motor.

If all these are in order, remove the cover band and inspect the brushes and commutator. The brushes should form good contact with the commutator and the commutator must be reasonably clean and smooth. If it is not, it should be cleaned or turned down in a lathe as explained under "Maintenance," *Six Months or 6,000 Miles* above. If there are burned bars on the commutator, it may indicate open-circuited armature coils which will prevent proper cranking. The remedy is to re-solder the connections at the commutator riser bars and turn down the commutator in a lathe.

If leads have been thrown out of the armature slots, the indication is that the over-running clutch caused the armature to be spun at an excessive speed due either to a defective clutch or to the fact that the operator of the vehicle was not starting the engine in the proper manner. If the operator opens the throttle too wide on initial starting or if he keeps the starter pedal depressed for too long after the starting has been accomplished, the over-running clutch may overheat and partially bind so that the armature is spun at excessive speeds. In addition to ruining the armature, the over-running clutch also will be ruined by such abuse. Evidences of excessive over-running of the clutch are wear of the clutch bearings, depositing of bearing material on the armature shaft, and a smooth face in the collar on the side closest to the pinion.

Tight or dirty bearings or worn bearings, bent shaft, or loose pole shoe screws which would allow the armature to drag will reduce armature speed or prevent the armature from turning.

If the brushes, brush-spring tension, commutator, etc., all appear in good condition, it will be necessary to remove the cranking motor for further test.

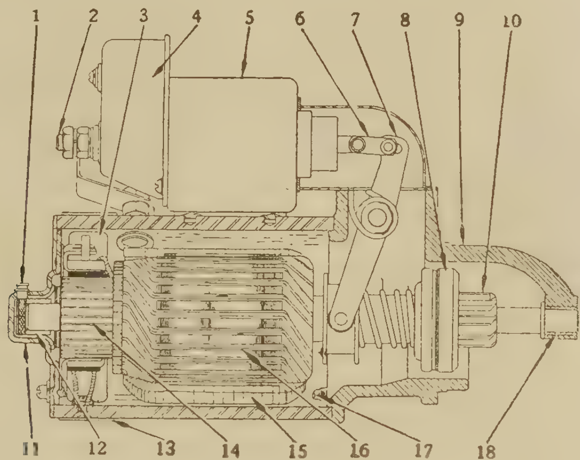


Fig. 290.—Delco-Remy Starting Motor.

1, Oil Cup.
2, Terminal.
3, Brush.
4, Solenoid Relay.
5, Solenoid.
6, Shift-lever Linkage and Adjusting Stud.
7, Shift Lever.
8, Clutch.
9, Pinion Housing.
10, Pinion.
11, Armature Bushing Support—commutator end.
12, Armature Bushing—commutator end.
13, Inspection Cover.
14, Commutator.
15, Field Coil.
16, Armature.
17, Pinion Housing through Bolt.
18, Pinion-end Bushing.

Bench Checks

No-load Test.—Connect the cranking motor in series with a battery of the specified voltage and an ammeter capable of reading several hundred amperes. If an r.p.m. indicator is available, read the armature r.p.m. also.

Torque Test.—Torque-testing equipment such as illustrated in Fig. 289 may be used to determine if the cranking motor will develop rated torque. A high current carrying variable resistance should be connected into the circuit so that specified voltage at the cranking motor may be obtained, since a small variation in the voltage will produce a marked difference in the torque developed.

The manufacturers will supply data concerning the brush-spring tension, no-load amperage, voltage and speed and the lock test, amperage, voltage and torque values for the range of models supplied.

In connection with the brush-spring tensions these fall into two groups, according to the particular models, the values being 24–28 ozs. and 36–40 ozs. respectively.

Fig. 290 shows the 12-volt starting motor used on certain American cars. It employs a solenoid mounted on top to operate a lever (at 7) to shift the starting-motor pinion 10, through the agency of a clutch, to the right so as to engage with the flywheel teeth. It will be observed that the motor armature shaft has a bearing at the extreme right-hand side.

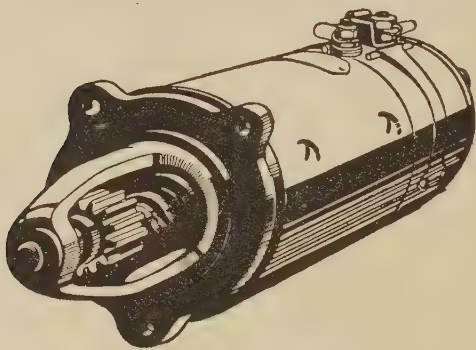


Fig. 291.—C.A.V. Non-axial Starter.

Commercial-vehicle Starting Motors

Two different types of electric starting motors, subsequently referred to as "starters," are employed for commercial vehicles, namely, the *Non-axial Starter* and the *Axial Starter* (Figs. 291 and 292). Usually, these are similar in regard to certain electrical details, e.g. the armatures and brush gear, etc., so that the general information on their maintenance is applicable for such items.

The two types of starter, commencing with the axial type, are described in the following pages.

The commercial-vehicle starters, except for light delivery-van chassis, generally employ special solenoid-type starting switches, particulars of which are given later.

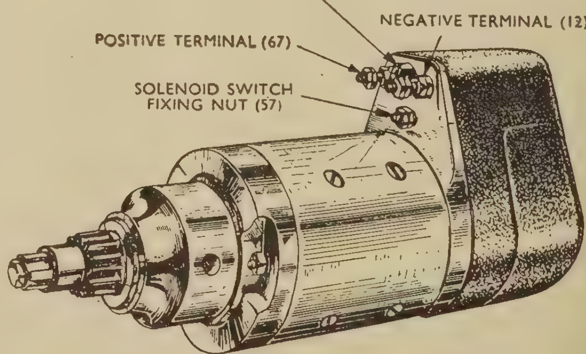


Fig. 292.—The Simms Axial Starting Motor.

Axial Starting Motor

The axial type of starting motor, of which the C.A.V. is a good example, is fitted to different makes of commercial vehicle. It is so called since the armature with its shaft is capable of axial movement in its bearings. When extended its shaft engages the pinion with the teeth on the flywheel rim. It is held in a disengaged position by means of a spring fitted inside the shaft at the commutator end, the armature being thus kept out of complete register with the pole shoes.

The field winding of this machine is divided into the main series winding

and the auxiliary series winding and a shunt winding. When the starter switch is operated a small current passes through the shunt and auxiliary field windings causing the armature to commence to rotate slowly.

Simultaneously, the magnetic field set up pulls the armature forward and brings the pinion gently into mesh with the engine flywheel teeth. This movement also causes the tripping disc to operate the tripping lever attached to the contacts of the solenoid switch which completes the main circuit. The full current from the battery then flows through the armature and series winding, the motor then entering its full torque. When the engine starts the motor current is reduced, the magnetic field diminished, and the tension of the spring overcomes the magnetic force, thus disengaging the pinion. Even if the starter switch is kept engaged the starter will not again couple up with the flywheel rim teeth, but will continue to run free.

This is not the case, however, with motors fitted with "holding-on" windings in which the pinion is held in mesh with the flywheel teeth until the starter button is released. On some machines this arrangement is carried a step further, the pinion being held in mesh until either the cut-out points close or the starter button is released, disengagement being effected by whichever operation occurs first.

"Holding-on" windings on certain types of axial starters have the effect of reducing the number of engagements necessary to start the engine. Another special feature of the axial starter is a unique overload device which prevents damage occurring during an engine backfire. This consists of a single screw and spring-loaded clutch arrangement which has a slipping torque about three times the lock torque of the starter, but is below the shearing strength of the starter pinion teeth so that instead of breaking the pinion teeth the clutch slips under excessive load. A modified design, known as the "two-step" clutch, is fitted to certain motors; this not only prevents damage through backfires but also prevents any load being taken by the pinion until it is in engagement with the flywheel teeth. The phosphor-bronze pinion is designed to withstand all normal working conditions, but should any wear occur it takes place on the pinion and not the flywheel teeth, thus reducing maintenance costs.

Avoiding Excessive Pinion Wear.—In this connection *it is important to note* that following a failure of the engine to start, after "firing," to allow both the engine and starter to come to rest. Otherwise, the teeth on the phosphor-bronze pinion will be milled away quickly, causing complete failure of the starter and the expense of fitting a new pinion.

The C.A.V. Axial Starter Motor

It is now proposed to describe in more detail the starter fitted to heavy oil-engine vehicles, e.g. the Leyland "Comet" and A.E.C. "Mammoth Major."

The starter, which is shown in dismantled form in Fig. 293, is the C.A.V.

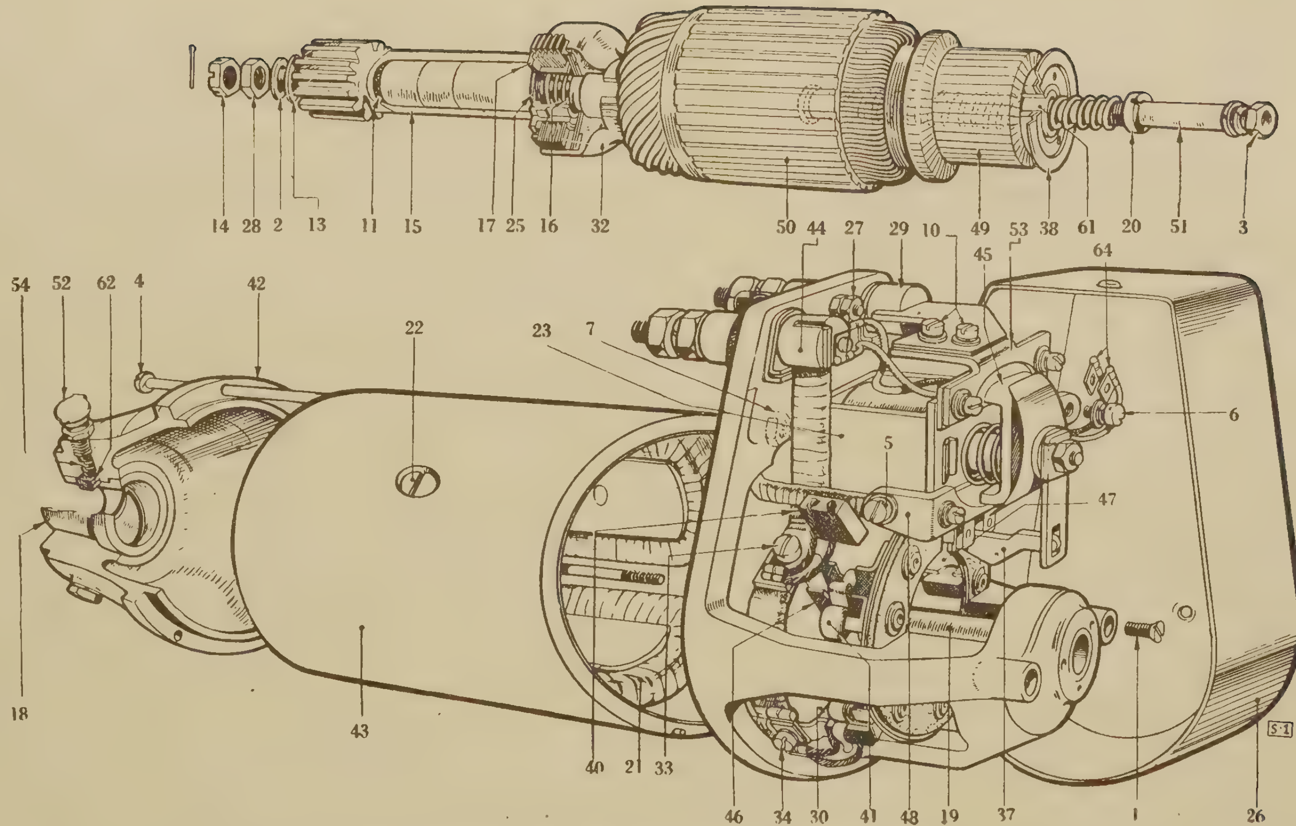


Fig. 293.—The C.A.V. Axial Starter, as fitted to Leyland Vehicle.

Major components: 4, Through Bolts. 7, Switch Fixing nut. 10, Positive Terminal Screws. 15, Pinion. 16, Clutch. 21, Field Coils. 22, Pole-fixing Screw. 23, Solenoid Cover. 26, Casing. 29, Positive Connector. 30, Brush Spring. 32, Clutch Housing. 34, Brush Guide Screw. 37, Trigger. 38, Trip Plate. 40, Brush. 43, Outer Casing. 44, Negative Terminal. 45, Moving Switch Contact. 47, Positive Brush Holder. 48, Second Contacts. 49, Commutator. 50, Armature Outer Casing. 52, Lubricator. 53, First Contact. 54, Spring. 62, Felt Pad in Lubricator.
Note.—Other numbers refer to spare parts numbers.

Type BS5224K, operated from a 24-volt battery. It has a reduction ratio to engine flywheel ring of 13·25 : 1. It employs *a clutch "overload" device* (Fig. 294) to prevent any damage occurring due to an engine backfire. This is a simple screw and spring-loaded clutch which has a slipping torque about three times the lock torque of the starter, but it is below the shearing strength of the pinion teeth, so that the clutch will slip instead of the pinion teeth shearing under excessive loads.

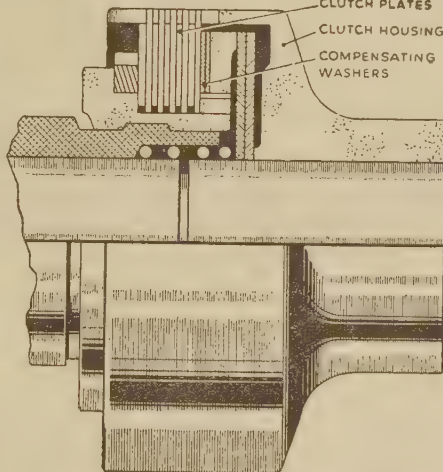


Fig. 294.—The Leyland C.A.V. Starter Clutch Overload Device.

A special starter switch of the solenoid type—shown in exploded view in Fig. 295—is used in conjunction with this starter motor.

The field winding is divided into (*a*) two main field coils, (*b*) two auxiliary coils, each made up of an auxiliary shunt coil, and (*c*) an auxiliary series coil. When the starter button is operated the magnetic field set up in the switch windings draws in a plunger until the trigger catch plate (38) (Fig. 293) rests on the step in the trigger (37). This movement closes the moving contact (45 long arm) on to fixed contact (53); this completes the auxiliary and shunt-field coil circuits giving the starter armature its axial movement, and gently but positively engages the pinion with the teeth on the flywheel ring.

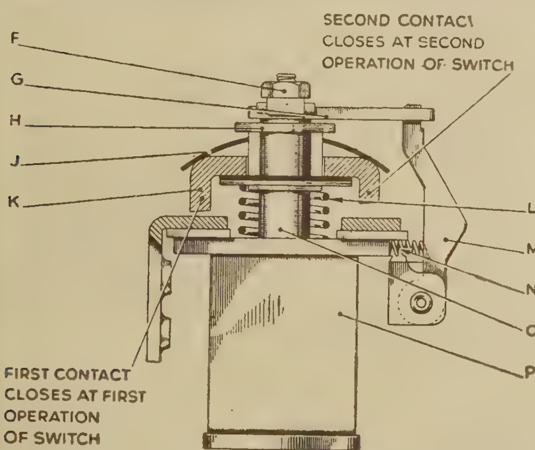


Fig. 295.—The C.A.V. Starter Switch (Leyland Vehicles).

F, Plunger Nut. G, Trigger Catch Plate. H, Adjusting Washers. J, Leaf Spring. K, Moving Contacts. L, Main Return Spring. M, Trigger. N, Trigger Spring. O. Plunger. P, Solenoid.

This travel of the armature trips trigger (37), permitting the plunger to be drawn farther in, closing contact (45 short arm) on to second contact (48). Thus the circuit through the starter main series coils is completed and the starter develops its maximum power.

Testing the C.A.V. Axial Starter Motor.—Before testing the starter in position on the vehicle, see that the battery is fully charged and that all cable connections on the battery, starting motor, and the switches are secure.

(1) Push the starter switch button. If the motor does not start, connect up a voltmeter of 0 to 30 volts between SOL and negative terminals on the starting motor. Then push the starter button again. If the voltmeter gives no reading, examine for a fault in the cable between the starter button and motor, or in the windings of the solenoid switch.

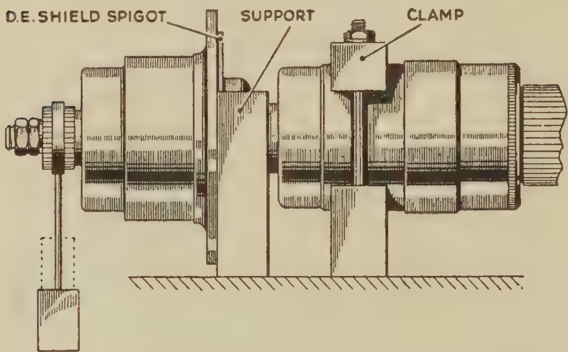


Fig. 296.—Testing Leyland C.A.V. Starter. The Torque Lever and Clutch Clamp are shown in this illustration.

(2) Push the starter button, and if the solenoid clicks this will indicate that the solenoid is working on the first contacts (53) (Fig. 293) only, but that full current is not being supplied to the motor. Faulty armature adjustment or a worn trigger may be the cause.

(3) If the starter should "crash" into engagement the trigger (37) (Fig. 293) and plate (38) should be examined for wear.

(4) If the starter operates intermittently when the starter button is held down this may be due to the second contacts (48) on the solenoid switch being burnt or to wear of the motor bushes.

(5) If the bearing (18) at the driving end of the motor becomes worn, this will result in slow engagement and considerable loss of power owing to the armature touching the pole pieces.

(6) Should the motor operate without cranking the engine this is due possibly to a slipping clutch or worn flywheel teeth. Another possible cause is movement of the starter in its mounting away from the flywheel.

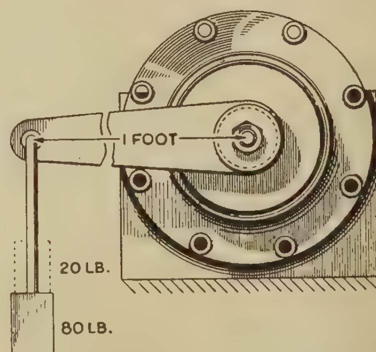


Fig. 297.—The Torque Test on Leyland C.A.V. Clutch.

Checking and Adjusting Starter Clutch

It is essential that the overload clutch on commercial-vehicle starters should be adjusted correctly after overhaul, long service, or replacement, to ensure that the slipping torque is correct.

The method of testing the clutch used by Leyland Motors, Ltd. is illustrated in Figs. 296 and 297. The clutch is clamped in a special fitting, shown on the right in Fig. 296, and supported at the D.E. shield spigot. An arm 1 ft. long is fixed as shown and a weight pan arranged. When newly assembled the clutch should be adjusted to slip at 100 to 115 ft.-lb.

The tests should be repeated several times, using weights of 100 to 115 lb. at the end of the lever.

If the clutch slips at less than 80 ft.-lb. a compensating washer (Fig. 294) must be fitted between the clutch plates and the back ring. Washers are supplied in thicknesses of ·004 and ·006 in. and one or more must be inserted as required.

The Simms Starter Motor

This motor, fitted as an alternative to the C.A.V. one on certain Leyland and A.E.C. vehicles, is shown in section in Fig. 298 and externally in Fig. 292. It is of the 24-volt type, with a reduction-drive ratio of 13·25 : 1.

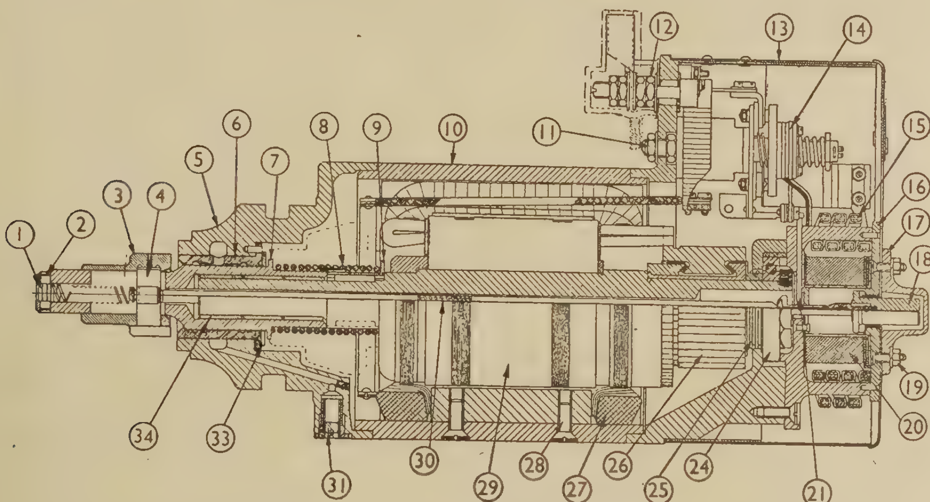


Fig. 298.—The Simms Starter Motor (A.E.C., Ltd.).

1, End Plug. 2, Cross Dumb-bell. 3, Pinion. 4, Cross-key. 5, Nose. 6, Plain Bronze Bearing. 7, Splined Shaft. 8, Clutch Spring. 9, Driving Sleeve. 10, Outer Cylindrical Casing. 11, Solenoid Switch Fixing Nut. 12, Solenoid Terminals. 13, Casing. 14, Solenoid Switch Assembly. 15, Heavy Series Coil. 16, Solenoid End Plate. 17, Plunger Cover. 18, Plunger. 19, Cover Nut. 20, Core. 21, Washer. 24, Ball Race. 25, Labyrinth Seal. 26, Commutator. 27, Field Winding. 28, Pole-securing Screw. 29, Armature. 30, Push-rod Spring. 31, Lubricator. 33, Washer. 34, Bushes.

The commutator end of the shaft runs in ball bearings and the driving end in phosphor-bronze bushes. A ball thrust is fitted to the push rod.

When starting from rest (lock torque conditions) the current taken is 1,200 amperes. The lock torque is 90 lb.-ft. falling to 32 lb.-ft. at the maximum motor output, which is 5·8 b.h.p. at 950 (motor) r.p.m. The spring pressure per brush is 1 lb. 13 ozs.

This series motor has four field windings connected in parallel with each other, as shown in Fig. 299, and in series with the wave-wound armature. The drive is transmitted through a spring release clutch and

the pinion is moved axially into engagement with the flywheel teeth by means of a double-wound solenoid at the commutator end.

The solenoid switch, also mounted at the commutator end of the starter, functions in two movements. When the starter button is pressed the first moving contact snaps down on to the fixed contact plate, further movement being prevented by a plate which is held against the notch on the trigger. As the engagement solenoid meshes the starter pinion with the gear ring on the flywheel, it releases the trigger, and the switch then closes the second contact which applies full voltage to the armature and field circuit.

Lubrication of Motor.—The ball-race and the thrust-race on the push-rod at the commutator end of the armature shaft are packed with high-melting-point grease, and should receive attention at overhaul. The spring-release clutch is packed with graphited grease, and should receive attention after the same period. On the driving end of the armature shaft three "Oilite" bushes are pressed on. At overhaul the "Oilite" bushes should be lightly lubricated with thin oil.

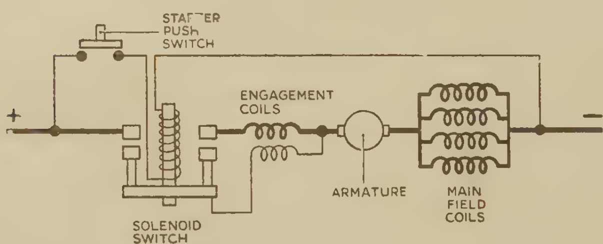


Fig. 299.—Wiring of the Simms Starter.

Every month the driving end nose bearing should be lubricated through the screw in the nose with light machine oil. The splined shaft, upon which the pinion slides, must be maintained clean and free from dirt and should be lightly lubricated with thin oil after overhaul.

Testing the Starter Motor.—The general procedure for testing and inspection of the starter and switch system is similar to that previously described for the C.A.V. motor.

Performance Check of Reconditioned Simms Starter Motor.—The following method applies in general to the Simms Type 6245GR23 starting motor illustrated in Figs. 292 and 298.

Connect the starter up to a battery in the normal way, connecting a small push switch between the solenoid terminal and the positive terminal. Insert a strip of paper under the second contact of the solenoid switch and press the small push switch to energise the solenoid. The first contact should close, the armature revolving in a clockwise direction looking on the pinion end, and the pinion travel forward for a distance of approximately 1 in., where it will remain revolving as long as the push switch is depressed. *Do not prolong this test.* Repeat this test after removing the paper from under the second contact, when the starter will operate as previously but at a much higher speed, the pinion returning automatically to the disengaged position, revolving at high speed until the push switch is released.

Lock Torque Test.—In addition to these tests the motor should be given

a lock torque test to ascertain the breakaway or starting torque and current, in the manner previously described on page 276. The lock torque should be 90 lb.-ft. and starting current 1,200 amperes.

Maintenance of Axial-type Starters

Provided that reasonable care is taken when operating this type of starting motor, it will give trouble-free performance over a long period.

When mounted on the engine in the case of the C.A.V. starter it should give a pitch-line clearance of ·015 in. to ·025 in. (Fig. 300). Further, it should be possible to withdraw the commutator end cover and inspect the brushes without removing the starter from the engine.

The Brush Gear.—The brushes should be inspected at regular intervals, say every 25,000 miles, and they should always be free in their guides, with their flex leads quite clear for movement. When special fibre insulation is provided for the brush flexes it should be examined for charring—a cause of short circuits.

The positive and negative brushes must be insulated from one another. They can be tested by means of a lamp as used for testing field coils and other insulation. The brushes need only be lifted from the commutator for this test.

If a brush is removed it must be replaced in exactly the same position in the brush holder, to ensure the same bedding curvature of the brush on the commutator.

On insulated-return motors the brush gear is insulated from the rest of the motor.

The brushes when refitted to a motor *should be well bedded down.* If not, wrap a strip of very fine glass- or carborundum paper firmly around the commutator and with the brush in position rotate the armature by hand in the proper working direction of rotation until the correct brush shape is obtained. The brushes on a motor should not wear down so that the trigger or spring is not giving effective pressure.

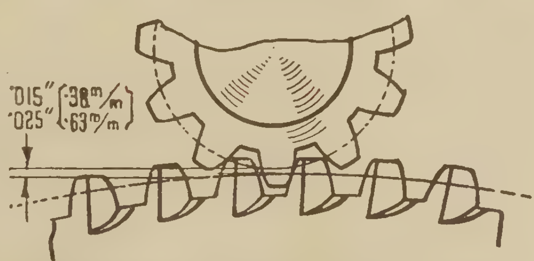


Fig. 300.—Mounting of Axial Starters (Flywheel Clearance).

The brush-spring pressure value is very important. It should be tested by means of a spring balance hooked under the spring trigger or spring tips, and its value for the various types of C.A.V. axial starter motors should be as follows:

SC, S5, ZBB, ZAB 12v.	24–32 ounces
ZAB 24v.	36–48 ,,
BS5 12v., BS5 24v.	32–40 ,,
BS6 12v., BS6 24v.	18–24 ,,

Armature Maintenance.—The commutator surface should be clean and free from uneven discoloration. There should be no deposit bridging the segments across the inter-segment insulation.

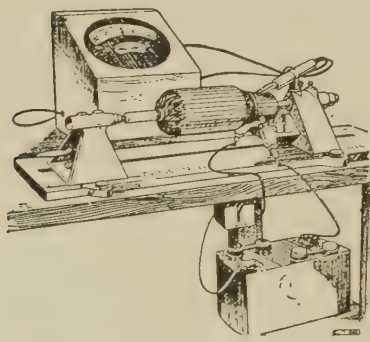


Fig. 301.—Method of Testing Armature Coils.

The surface can be cleaned with a very fine grade of glass- or carborundum paper (do not use emery cloth) except in cases where it is in a very badly pitted condition, when it should be set up on a lathe and skimmed. A very light cut should be made and, where possible, a diamond tool be used, in order to provide the desired high-quality finish.

The armature (where stated) should be "undercut," i.e. the mica insulation between the commutator bars, in the C.A.V. starters, should be removed to a depth of $\frac{1}{32}$ in. (·8 mm.) below the surface of the copper, care being taken to remove the full width of mica and to leave nothing to project above the copper.

The respective armature coils can be tested for continuity or short circuits by mounting the armature on a block and connecting the commutator to an ordinary car battery through the medium of two brass or copper brushes mounted at an angle of 90° to each other. Contact is then made to any two adjacent commutator bars by means of hand spikes which are connected direct to a millivolt meter (see Fig. 301).

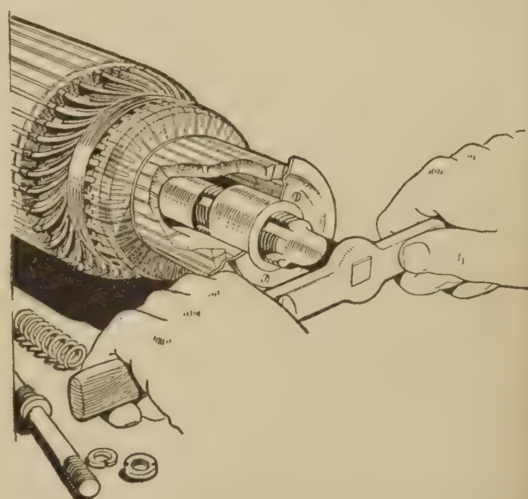


Fig. 302.—Extracting the C.A.V. Axial Starter Oil-less Bush.

A variable resistance included in the battery circuit should be capable of carrying the full output of the battery and adjusted to give 2 volts or less on the armature. The armature is then rotated until every commutator bar has been tested, the reading on the millivolt meter in each case should read approximately the same; any big variation indicating a fault in the coil connected to one of the commutator bars under test. A reduction in the millivolt reading will generally be found due to a short circuit, while an increased reading will indicate either an open or a faulty connection.

It should also be mentioned that the "Growler" armature tester is to be recommended for starter-motor armature testing; indeed, it may be regarded as almost a necessity for both starters and dynamos.

Field Coils.—These can be simply tested when in position for short circuits to the yoke and poles by means of hand spikes connected to a mains supply and in series with a lamp of suitable voltage positioned on the live side of the system. One spike should be applied to the end of the winding and the other to the yoke at a suitable position where it is free from enamel and insulation. If the lamp does *not* light, then the insulation is intact. Take care to first remove all other connections to the coils and to insulate any bare ends.

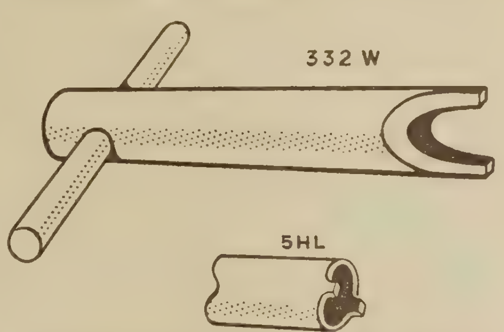


Fig. 303.—Special Tools for Dismantling the C.A.V. Axial Starter.

Internal shorts can be traced by means of an ohm-meter. As the resistance of the coils should be within 6 per cent. of each other, the most satisfactory method is to compare for excessive variation the resistance of the suspected coil with each of the remaining individual coils in the set.

It will generally be found that the total resistance of C.A.V. main starter field coils will be from ·001 to ·003 ohm, approximately, per set, for 6-, 12-, and 24-volt machines.

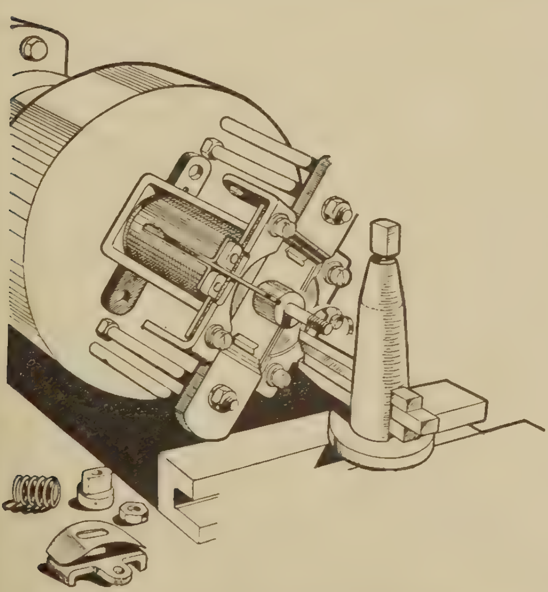


Fig. 304.—Method of Refacing Solenoid Switch Contacts.

Dismantling Axial Starter.—*Special Tools for Dismantling.*—To facilitate the dismantling of C.A.V. axial starter motors two special tools have been devised, namely the types 332W and 5HL shown in Fig. 303.

Type 332W tool is employed for the motor armature spring nut and regulator adjustment.

The tool 5HL is used for the armature plunger nut. There is another somewhat similar tool, Type 842X, that is used for another model starter. In connection with these tools, the detailed step-by-step instructions of the

manufacturers, a copy of which can be obtained on application to the firm, should be followed. The lettered sectional illustration reproduced in Fig. 293 will also be found very useful when dismantling and reassembling the starter.

The method of extracting the C.A.V. axial starter oil-less bearing bush is shown in Fig. 302. A standard $\frac{7}{8}$ in. B.S.F. tap and a steel rod of $\frac{3}{8}$ in. diameter by $7\frac{1}{8}$ in. long are all that are required. After removing the pinion spring and saddle, drop the steel rod into the cavity and then tap into the bush until the tap bottoms on to the rod. Continue turning the tap wrench, when the bush will be slowly forced out.

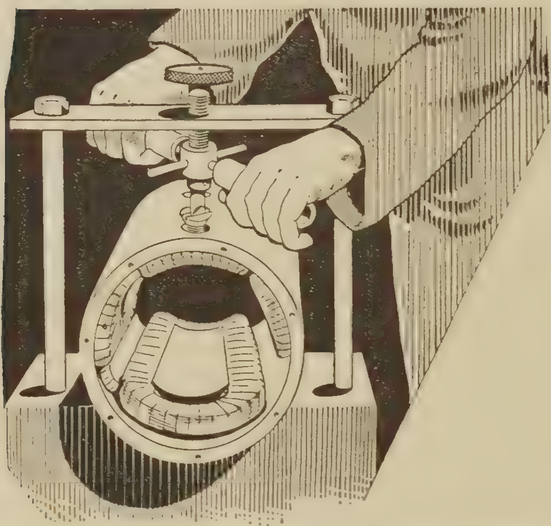


Fig. 305.—A Device for Unscrewing C.A.V. Pole-piece Screws.

Fig. 304 illustrates the method recommended for refacing the solenoid switch contacts of the C.A.V. axial starter, by mounting them in a lathe and turning the surface with a suitable lathe facing tool. New contacts may be trued in the same manner.

The method of removing and refitting pole pieces of dynamos and motors is illustrated in Fig. 305. The rig shows how a powerful effort is applied to the flush-head screws holding the pole pieces, using the screw-down screw-driver blade arrangement shown. It is very important to screw the pole pieces down tightly to avoid armature failure, by fouling these items.

Changing Starter Pinion

It is possible to change the C.A.V. starter pinion without dismantling the starter motor by removing the split pin and slotted nut from the armature shaft (Fig. 306), after which the motor is stood on end with the pinion above. The thin shaft nut is loosened, whilst keeping the pinion held firmly against its spring pressure plate. Then, whilst still keeping resistance against the spring, the pinion should be turned in the opposite direction to that of normal rotation, pressure being gradually released until the pinion is unscrewed.

Operation of Axial Starters

The following notes, in the form of operational instructions, should be observed carefully when using axial starters:

Make sure all engine controls are correctly adjusted.

Release the switch as soon as the engine fires.

If the engine does not fire at once, allow it to come to rest before pressing the starter switch again.

Do not use it continuously if the engine does not start. Ascertain the cause of failure.

With some engines it is often helpful to depress the clutch when starting.

On no account should it be operated while the engine is running, otherwise serious damage is likely to occur to both starter and flywheel teeth.

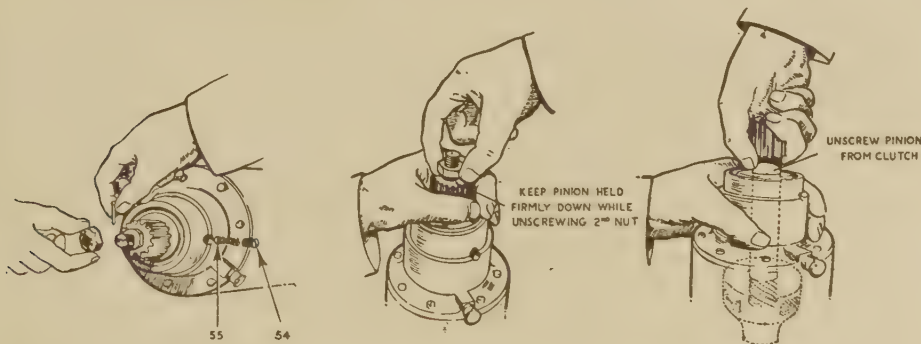


Fig. 306—Method of Removing Starter Pinion without Dismantling Starter Motor.

General Maintenance Notes for Starters

The following instructions apply to C.A.V. starters of different types and are in the form of "*Do Not*" instructions.

Do Not.—Attempt to rebore the poles or re-machine armature core, as this will upset the engaging action of the starter.

Use other than proper brushes, as in correct grades will mean excessive sparking, resulting in bad commutator surface and pitting.

Use lubricants other than those mentioned unless they have been submitted to the manufacturers for approval. Incorrect lubricants will cause excessive bearing wear.

Damage armature core when holding it for torque test of clutch, as short circuits in the windings may occur or the air gap between poles and armature may be affected.

Bend or damage switch tripping plate on armature, otherwise the timing of the pinion engagement will be altered.

Let oil or dirt come in contact with the commutator, since this will cause short circuits between the commutator bars, uneven brush wear, a bad commutator surface, and breakdown of insulation.

Be over-enthusiastic with lubricant in the driving-end lubricator. Oiling is very necessary, but if excessive, saturated windings will result and cause premature breakdown of the insulation.

C.A.V. Non-axial-type Starters

This type of electric starting motor is a simple series-wound motor fitted with a special pinion gear for easy engagement with the teeth on the flywheel rim. The method of drive varies slightly, according to the particular requirements, but the majority of commercial types have a quick-start threaded sleeve mounted on the main shaft along which the freely-mounted pinion travels into engagement with the engine flywheel. The actual shock of engagement is absorbed through a large-section coil spring. Oil-less bearings are fitted on the latest models, dispensing with the necessity for periodic lubrication by the user.

When ordering spares or fittings, particulars of the motor as given on the name plate should be quoted.

Fitting Non-axial Starters.—*When fitting non-axial starters* to motor-vehicle engines the following information may be found useful:

With cast-iron flywheel gears it is unnecessary to provide any chamfering or rounding of the teeth, and they may be left exactly as finished by the gear cutter. There must be no radius on the corner of the gear blank.

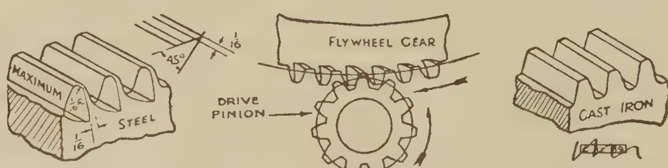


Fig. 307.—Flywheel Construction and Teeth Chamfering.

When a steel gear ring or a material having the malleable characteristics of steel is utilised, it is necessary that the teeth be chamfered on the non-pressure side at an angle of 45° and intersecting the end face of the tooth in a line approximately parallel to the pressure side and $\frac{1}{16}$ in. (1·6 mm.) there from Fig. 307. There may be a radius of $\frac{1}{16}$ in. (1·6 mm.) on the corner of the gear blank, and it is recommended that the whole ring be so treated as to have a scleroscope hardness in excess of 55 after mounting. The stub-tooth form is used with a pitch of 8/10 and a pressure angle of 20°.

Maintenance of Non-axial Starters.—The following information, whilst of general application to most designs of electric starting motor, is of particular interest to C.A.V. starter users:

Whilst very little attention is necessary, in order to provide for the longest possible trouble-free life the following items should be inspected at periods depending upon service conditions:

(*a*) *Armature.*—The commutator should be examined approximately every 25,000 miles or 6 months.

For full particulars of armature maintenance refer to General Instructions section (page 290).

(*b*) *Drive.*—The screwed sleeve should be cleaned with paraffin and lubricated with thin machine oil, so that the pinion is perfectly free in travel. The pinion teeth must not be damaged or worn. Where a light pinion return spring is fitted this should be examined. On pinions with counter-weights the small retarding plunger should operate quite freely.

(*c*) *Brush Gear.*—The brushes should be examined about once every 25,000 miles or at six-monthly road running intervals. See that the band cover is correctly replaced after brush inspection. The general notes on the brush gear and its maintenance given under "Axial Starters" are equally applicable to "Non-axial Starters."

(*d*) *Terminals.*—Keep all nuts tight and clean. Where rubber caps are fitted to cover the terminals they should not be dispensed with when connecting the cables; they are supplied as a safety factor. Polarity of the terminals is unimportant except on machines with solenoid switches mounted directly on the yoke; here the terminal markings must be adhered to.

(*e*) *Lubrication.*—Unless a greaser is provided no attempt should be made to oil or grease the bearings. When lubrication is provided for, *a soft grease* as used for chassis lubrication is recommended.

(*f*) *Bearings.*—Worn bearings should be replaced and *not rebored.* The makers undertake to remove and refit bearings to the original precision standards.

Starter Circuits for Commercial Vehicles

The 12-volt starting motor is used for the lighter and 24-volt motor for heavier vehicles, but the actual starter electrical circuit is the same for each type and is independent of the other circuits on the vehicle, e.g. ignition, charging, lighting and accessory supply circuits. The starter takes its electrical supply direct from the battery and this supply does not pass through the ammeter. The reason for this is that the ammeter is fitted to show the battery charging current, from the dynamo and also the discharge current when the lights are all switched on and the engine is idling, etc. The current readings seldom exceed 10 to 15 amperes under these circumstances, whereas if the starter current supply was to be indicated on the ammeter it would require an instrument reading to several hundreds of amperes, thus leaving far too small a scale for the dynamo charging circuit readings. In any case, it is unnecessary to read the starter current, since if the battery is not sufficiently charged to start the motor, this fact is at once evident.

The circuit for the starter is a simple one, the battery and motor being wired in series. The starter switch in the lighter types of motor is in series with the battery and motor. In the heavier types, e.g. the axial starter, the starter solenoid switch is wired as shown in Fig. 308 (upper diagram).

When a non-axial starter circuit is fitted with a solenoid switch the wiring is as shown in the central diagram of Fig. 308. The lower diagram

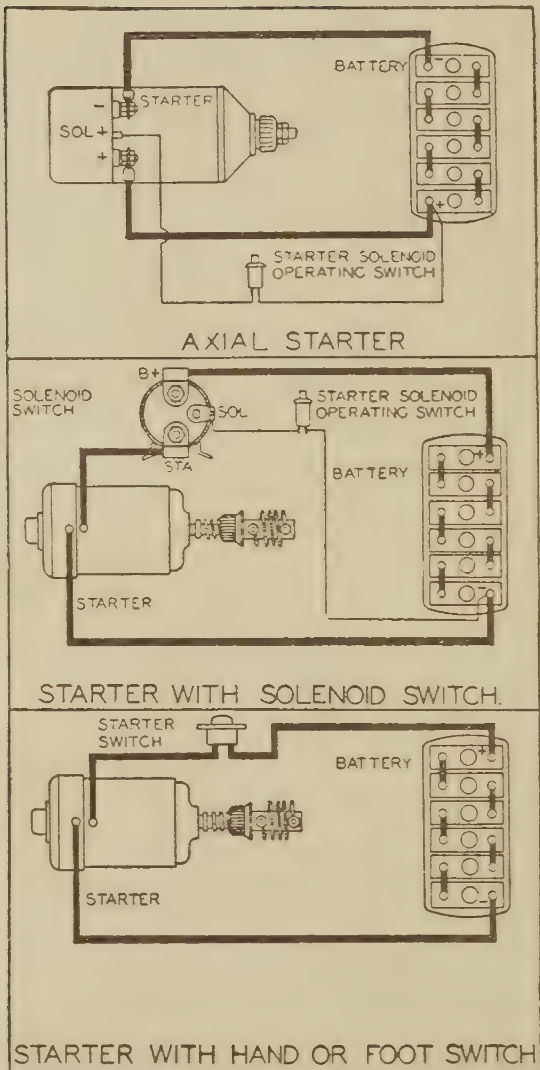


Fig. 308.—Starting-motor Circuits for Commercial Vehicles (C.A.V.).

shows the usual lighter model starter with ordinary starter switch wired in series.

Switches for Starters

Two principal types of switches are employed, namely, the direct-action and the solenoid ones. In either case the contact members are of able area, since very large currents must flow through them during the initial starting operation of the motor.

Fig. 309 illustrates the C.A.V. NZ-type starter switch for foot or hand operation and is intended for the smaller class of starters (up to $4\frac{1}{2}$ in. outside diameter).

Two heavy copper contacts A screwed on to the actual terminal studs B are contained within the pressed-steel body C. The circuit is completed between the two fixed contacts by means of the circular moving contact D which is located on the spring-loaded plunger E and is operated by pressing the moulded knob F. The fixed contacts are end-milled when they are assembled in the body, to ensure good alignment with the cone-shaped metal moving contact. Large cable connecting tags are provided.

In regard to *the maintenance of this type of switch*, it is necessary to keep the terminals and the surface on which they are mounted quite free from dirt, damp, or oil.

The terminal nuts H must be tight and care taken that the cable tags J do not twist and touch one another.

A smear of vaseline should be applied to the main plunger E, as necessary.

The contacts can be inspected after removing the top cover K with its fixing screws L. The contacts can be cleaned with spirit or fine carborundum (not emery) paper, unless badly pitted, when they should be renewed.

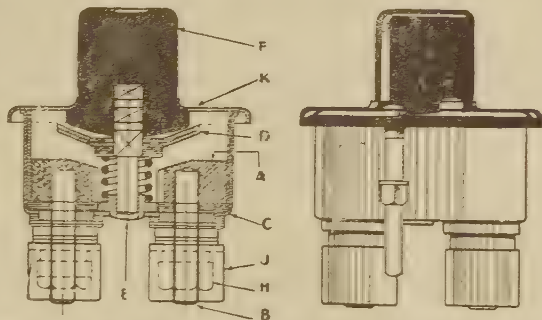


Fig. 309.—The C.A.V. NZ-type Starter Switch for Hand or Foot Operation.

Fig. 310 illustrates the *solenoid pattern of starter switch* which is used *for axial starters.* This is a simple two-step switch, such that at the first step the switch completes the circuit to the shunt and auxiliary field windings, allowing a small current to pass, sufficient to give the starter armature its axial movement, thus gently but firmly engaging the pinion with the teeth on the flywheel. When this engagement has taken place the second circuit is completed, allowing the main current to flow and the starter to develop its maximum power.

Referring to Fig. 295 on page 285, when the starter button is pressed,

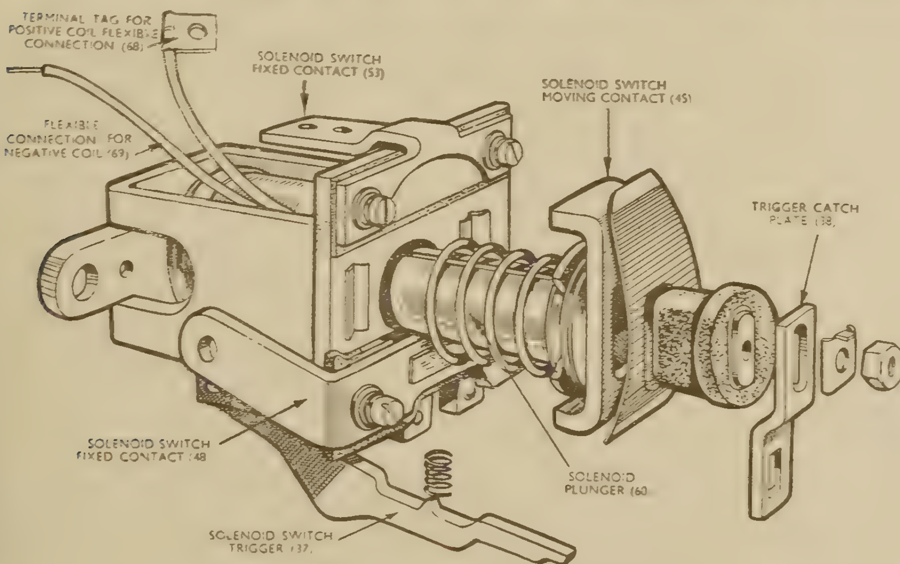


Fig. 310.—Typical Solenoid Starter Switch (A.E.C.).

the magnetic field set up in the switch windings draws in the armature O until the first contact is closed and the catch G rests on the step in the trigger M. This position is held until the trigger is lifted by the trip plate

on the armature during its travel and thus allows the second contact to close and the main current to pass.

Dismantling and Reconditioning Typical Solenoid Switch

As an example of the general method of dismantling and reconditioning the solenoid type of starter switch, that of the C.A.V. make illustrated in Fig. 311 has been selected. This pattern is used on certain Leyland vehicles.

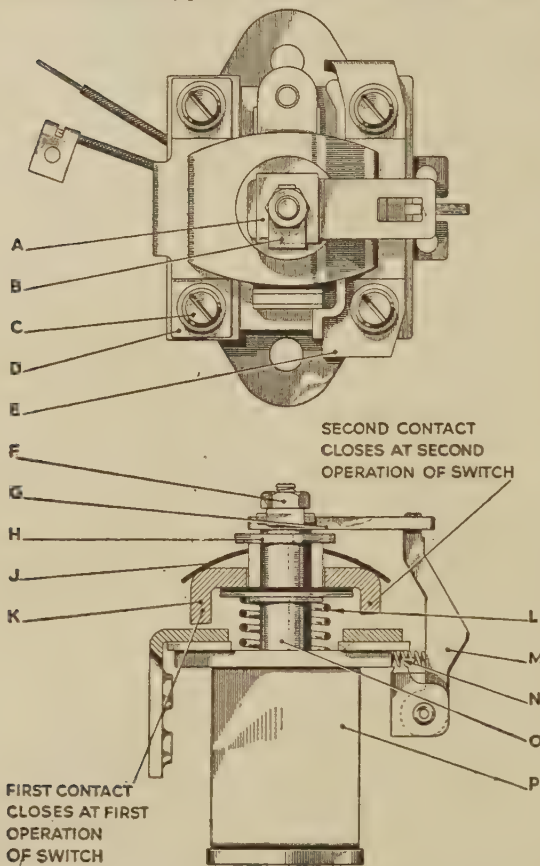


Fig. 311.—The C.A.V. Solenoid Starter Switch as used on some Leyland Vehicles.

A, Catch-holding Plate. B, Locking Washer. C, Contacts Retaining Screws. D, Fixed Contact Plate. E, Plate. F, Securing Nut. G, Catch. H, Insulating Bush. K, Bridge Piece. L, Spring. M, Trigger. N, Trigger Spring. O, Armature. P, Casing.

To Dismantle Switch.—To dismantle switch, release locking washer B (Fig. 311), remove nut F, catch-holding plate A, trigger catch G, bridge piece K with flat spring and insulating washer. Take care that trigger spring N does not fall out when catch is removed.

Note position of washers Q and R (Fig. 312), which are used for adjustment. The washer S acts as a spigot for return spring.

Remove fixed contacts by taking out retaining screws C (Fig. 312). If contacts are dirty, clean with spirit or fine carborundum paper.

If contacts are badly pitted, reface. When refacing don't remove more than $\frac{1}{64}$ in. The faces must be at an angle of 3° 49′ and in the same plane as shown in Fig. 313.

New fixed contacts are supplied unmachined and must be faced up in position on the switch. Don't use a file or coarse abrasive.

Check pressure of return spring L. When compressed to $\frac{1}{2}$ in. length, it should have a pressure of 5 lb. ± 5 ozs.; renew if not within limits.

Check pressure of trigger spring; it should have a pressure of $12\frac{1}{2}$ to 16 ozs. when compressed to $\frac{7}{32}$ in.

Check that insulating bush H is an easy fit in bridge piece and is not disturbed.

If winding is damaged or broken, fit new one.

Lightly smear the plunger O with vaseline at point of entry into body, also at point of contact between flat spring and bridge piece.

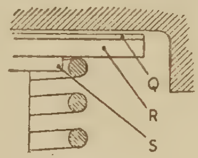
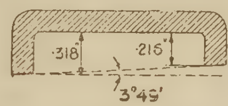


Fig. 312.



CONTACT FACES TO LIE IN SAME PLANE

Fig. 313.

Reassembly and Adjustment.—If contacts have been refaced, air gaps will require adjustment.

Adjusting washers Q and R (Fig. 312) must be removed and replaced until correct air gaps are obtained. Washers available are ·004, ·008, and ·012 in. thick.

The air gaps should be as follows:

First contacts ·040 in. $\pm$ ·004 in.

Second contacts ·142 in. $\pm$ ·008 in.

Trigger clearance ·079 in. $\pm$ ·004 in.

Fit new locking washer B (Fig. 311) for the armature nut.

Testing Solenoid Switch.—After assembly apply the following tests with the switch in a horizontal position:

Force to overcome return spring in " Off " position, 5 lb. $\pm$ 5 ozs.

Force to overcome return spring in " On " position, 29 lb. $\pm$ 2 lb.

Force to overcome spring tension of trigger M applied at peak of tripping face (Fig. 311) with switch in " Off " position, 16 ozs. $\pm$ $1\frac{1}{2}$ ozs.

Switch must operate on both contacts at 12 volts $\pm$ 1 volt.

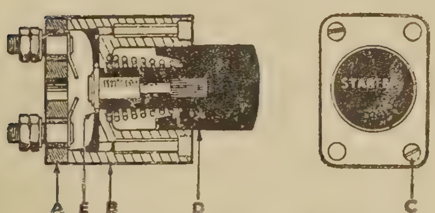


Fig. 314.—Typical Starter Button Switch.

Give switch a test of a few seconds' duration at twice normal voltage to ensure that trigger operation is correct. Faulty assembly or rounding of step will cause the catch to slip.

Keep the terminal nuts well tightened. Take care not to twist the cable sockets so that they jam against the small insulation cap, otherwise there is a danger of distorting the plunger bearing, with a consequent sticking of the plunger action.

Remove occasionally the screwed cap and plunger, smear the brass stem of the plunger with vaseline and replace.

Starter Button Switch

The switch used for energising the main or solenoid switch takes only a low current, and can therefore be made quite light. A typical switch is shown in Fig. 314. It consists of a moulded insulator A, secured to the metal body B by means of two countersunk screws C. The plunger is

shown at D. When pushed to the left against the spring, the central metal member E bridges the contact strips to which the terminals marked "plus" and "minus" are attached, and thus completes the circuit.

This type of switch must not, of course, be used to close or break main starter circuits, but only for the solenoid currents.

Testing Starting Motors

After a starting motor has been overhauled, or in cases where it is suspected that the output has fallen off, it is advisable to test the power of the starting motor. The usual arrangement is to fit the motor into some kind of clamping device, or cradle, and to measure the power output by means of a mechanical brake, or dynamometer, fitted to *the casing*. The principle of this method is that of measuring the turning moment, or torque, on the motor casing, this torque being equal to that of the armature shaft, although it is opposite in the directional sense.

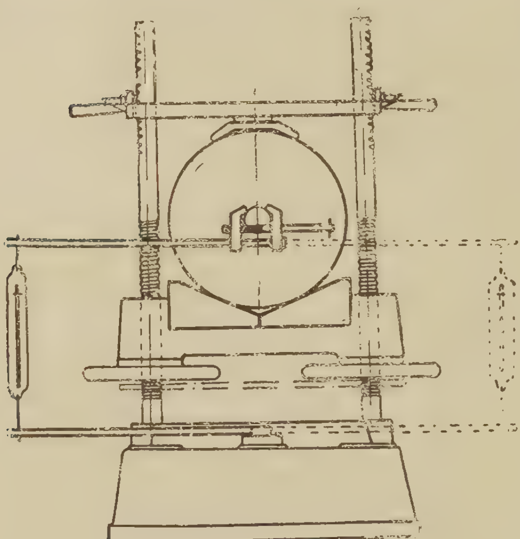


Fig. 315.—The Newton Test Bench and Torque Arm for Testing Starter Motors.

Fig. 315 illustrates another convenient method of measuring the torque, using the Newton test bench. It will be seen that the starting motor is held rigidly in the coupling vice provided. A special torque arm is supplied and is connected in the manner indicated to the armature shaft. Upon depressing the special starting switch provided, the starting torque is at once shown by the spring-balance reading. A comparison of this "lock torque" reading with that of a standard starting motor will show at once whether the output of the motor under test is correct in value.

Locating Faults in the Starting-motor System

(*a*) **Motor Fails to Operate.**—Look for a *break* or *disconnection* in the leads from battery or to frame; see that battery terminals are not loose. The *battery may be run down.*

A *broken armature winding* will also cause motor failure. Test by placing ammeter in series with a freshly charged battery and armature (Fig. 316); the motor should be rotated so as to test each commutator pair of segments.

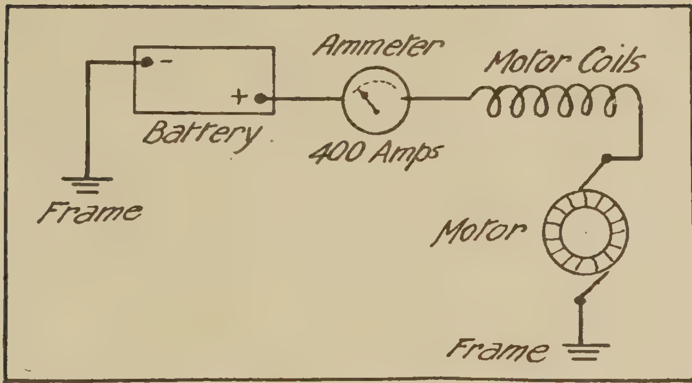


Fig. 316.—Test for Broken Armature Winding.

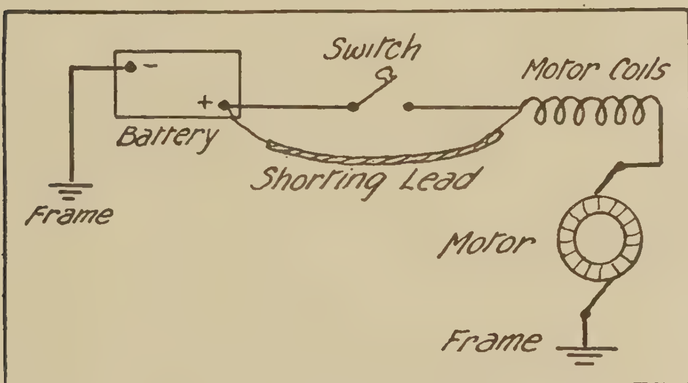


Fig. 317.—Test for Defective Switch.

FAULT-FINDING TABLE FOR STARTING MOTOR

MOTOR SLUGGISH OR FAILS TO MOVE ENGINE.				Engine partially or entirely seized.
				Oil too thick for winter use.
	ENGINE TURNS FREELY AND FIRES WHEN CRANKED BY HAND	MOTOR		Loose terminal nuts.
			BRUSHES	Greasy or dirty.
				Worn.
				Tight in holders.
				No spring tension.
			COMMUTATOR	Greasy or dirty.
				Worn.
		OPERATING SWITCH		Loose terminal connections.
		BATTERY		Exhausted.
				Broken or loose connections.
				Acid level low.

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The starting switch may not be operating; test by short-circuiting with a length of stout cable as shown in Fig. 317.

The engine may be seized or too stiff to operate, or the car may be in gear.

(*b*) **Motor Works Sluggishly.**—If the engine turns freely and fires when cranked by the starting handle this shows that it is certainly the starting-motor system at fault. The following are the likely causes:

Loose terminals on the battery, motor, or frame.

Commutator dirty, or mica too high; worn commutator.

Brushes greasy, not bedding properly, sticking in holders. No spring tension.

The battery may be partially exhausted.

The switch terminals may be loose.

CHAPTER 9

THE LIGHTING AND ACCESSORIES SYSTEM

THE general principles of the lighting and accessories circuits were explained briefly in Chapter 1. It is now proposed to consider this system in more detail.

The dynamo, which maintains the battery at full charge, need not be referred to here, since the whole of the electrical energy required for the various lamps and accessories, e.g. the horn, windscreen wiper, trafficators, motor heater, etc., is taken from the battery.

The *ignition* current supply in battery and coil systems is also taken from the battery; but we can omit the ignition circuit, since it has already been dealt with and is independent of the others mentioned. In all cases the various *electrical accessories are always wired in parallel* with the battery, so that, in effect, each component has a separate parallel wiring system from the battery or some point at battery potential, such as the lighting switch. Fig. 318 illustrates the principle of the lighting and accessories circuit and shows the various electrical items (with their switches) wired in parallel with the battery. The ammeter is included in this circuit also, and is usually of the double reading or " Charge " and " Discharge " pattern, for indicating the current value in either direction of flow.

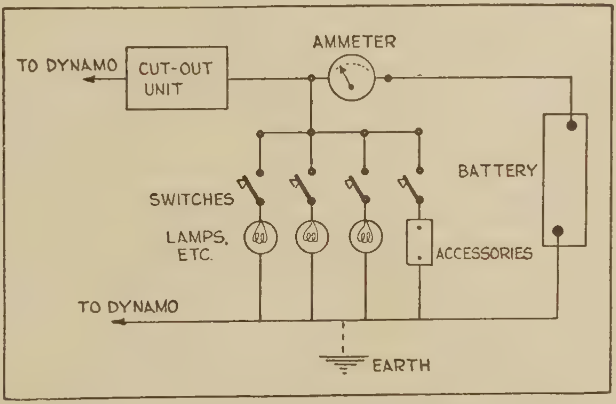

Fig. 318.—Illustrating Principle of Electric-lighting Circuit.

In all recent electrical systems, as previously mentioned, *the positive pole is earthed.*

The circuit in Fig. 318 is shown in simple form, but in practice the lighting circuit includes a junction box or distribution board, a switch of the selective type for switching on various combinations of lamps, such

as sidelamps and tail-lamp, or headlamps, sidelamps, and tail-lamps, or dimmer, sidelamps, and tail-lamps. In addition a fuse box is fitted carrying the lighting and accessories fuses. This box is often combined with the junction box or distribution board; sometimes it is mounted on the same panel as the cut-out.

In practice, as is explained more fully in Chapter 6, the lighting and accessories circuits are combined on the general electrical or wiring diagram of each make of car or other vehicle with the ignition, charging and starting circuits, since the battery unit is common to all these circuits. For the present purposes, however, we are concerned only with the electric lighting and accessories circuits, so that when one is given the complete wiring diagram it is necessary to trace these circuits. This is not a difficult matter if one remembers that all of the lamps and accessories are wired in parallel with the battery or some live terminal connected to the battery, the other parallel wire or connection being earthed to the chassis frame.

A good example of the combined wiring diagram is reproduced in Fig. 319, which shows the Morris Minor (series MM) wiring diagram.

Dealing with the lamps shown below, these are of the combined head- and sidelamp, there being a pilot bulb in each lamp which can be switched on when the main (and dip) filaments are " off."

The battery negative is connected to a common electrical control box (R.F. 95) by a cable (33) which goes to the terminal A, which is connected in turn to the terminals A1 and A2. The various lamps are connected to A1 through their cables and switches, as a close examination of Fig. 319 will show.

The horn, trafficators, windscreen wiper motor, electric petrol pump, and petrol tank level gauge are all supplied from the live negative terminals on the control box through their respective switches; some of these terminals are connected together within the control box so that it is not necessary to make common connections of the various live cables to a single terminal. The dynamo voltage-control unit is also housed in the common control box, as is the dynamo-battery circuit cut-out unit.

It should here be mentioned that the tracing of the various individual circuits of the lamps and accessories is simplified on the car by the use of cables of different colours. This system, which in Fig. 319 is illustrated by figures, for which a colour code cable is supplied, is explained in Chapter 6.

Tracing Troubles in the Lighting Circuit

The indications of the correct functioning of the lighting system (including the dynamo system) are the ammeter readings and the fact of the lights switching on satisfactorily.

The driver is usually only concerned with the switching on and off of the lights, and seldom troubles to make himself *au fait* with the wiring system, with a result that when trouble does occur—and when it does, total failure of the lights is the usual consequence—he is unable to trace it.

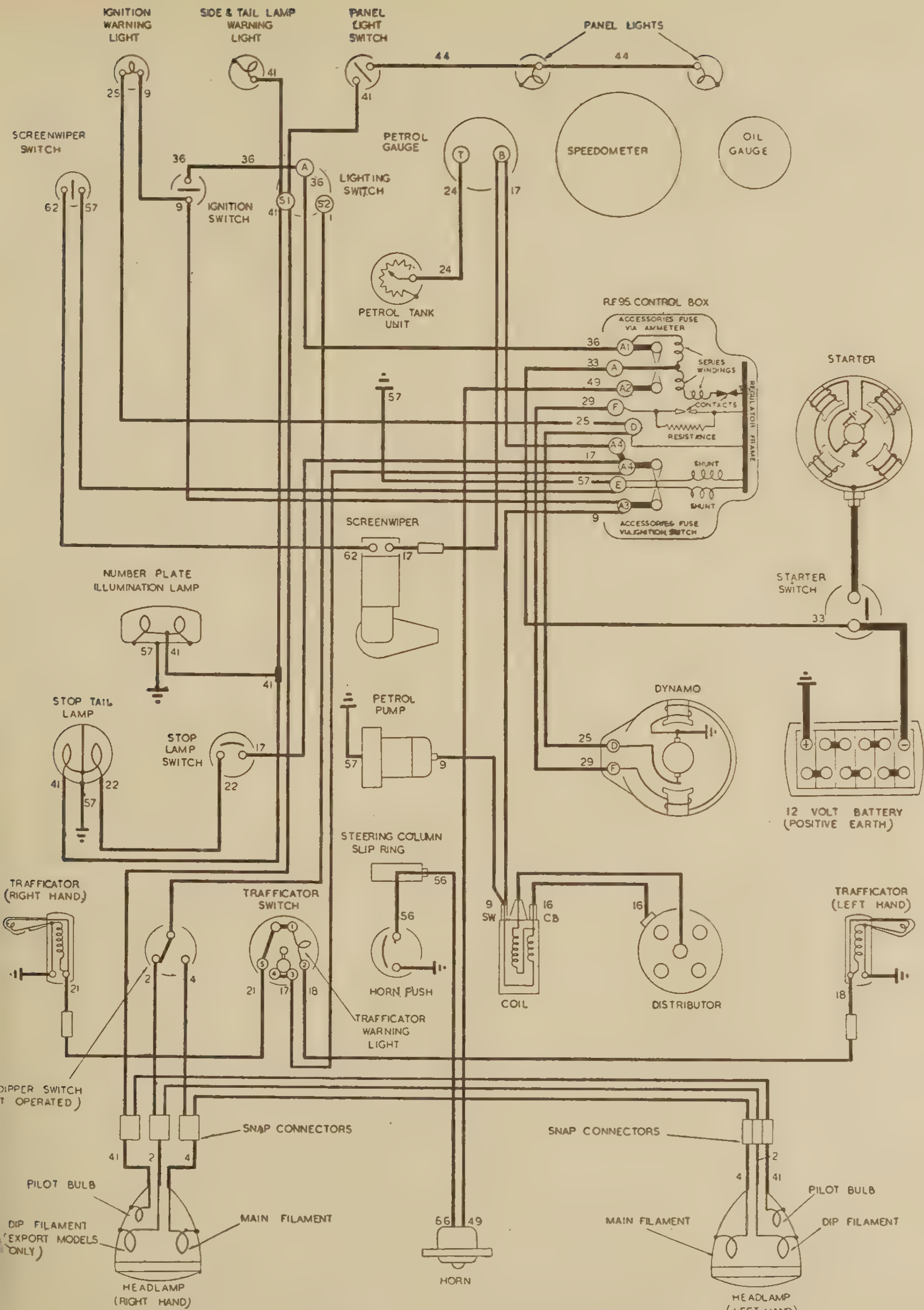

Fig. 319.—Wiring Diagram of the Morris Minor (Series MM) Car.

The following are the usual troubles experienced with the lighting system: (A) *Insufficient Illumination.* (B) *Ammeter Shows No Charge.* (C) *Lights Switch On, but Gradually Die Down.* (D) *Lights Glow Too Brilliantly.* (E) *Brilliance Varies with Speed of Car.* (F) *Lights Flicker* And (G) *Lamps Fail to Light when Switched On.*

(*a*) **Insufficient Illumination.**—This may be due to (1) a Run-down Battery, (2) Dirty Reflector, Lamp Cover Glass, or Bulb, (3) Lamp Out of Focus.

The voltage and acid density of the battery should first be tested, and if found to be satisfactory the lamps should be examined as indicated in (2) and (3).

An obvious, but occasionally unheeded, precaution is to observe that the correct candle-power bulb is used for each lamp. For sidelights and tail-lamp, 6- to 8-watt bulbs are used; for the headlights, 18-, 21-, 24-, or 36-watt bulbs are used; in the case of certain large cars, 48-watt lamps are sometimes fitted. For the dashboard 4- to 8-watt bulbs are usual.

(*b*) **Ammeter Shows No Charge.**—This may be due to either (1) a Blown Fuse in the Dynamo Field, (2) a Broken Connection in the Dynamo-Battery Circuit, or (3) Incorrect Reading Ammeter.

If the field fuse has blown owing to a broken connection in the circuit, a new one should be fitted, running the engine at a low speed to ensure that an excessive voltage is not generated. Always endeavour, however, to locate the cause of the fuse blowing before fitting a new one or it may blow again. Look for and tighten up loose battery connections, or terminals on the switchboard, fuse box, distribution or junction box, and on the dynamo itself.

A loose terminal connection may often be detected by trying to move the cable up and down in its socket; no play should be felt. The dynamo should also be examined to see whether it is charging properly.

If the ammeter is suspected—and it is an occasional source of trouble—test by disconnecting and substituting another instrument. A rough test may be made by noting whether there is any perceptible movement of the ammeter needle when the lights are switched on. It should read a discharge current equivalent to the total wattage of the lamps divided by the battery voltage.

For example, if we assume two 24-watt headlamp bulbs, two 8-watt sidelamp bulbs, one 6-watt tail-lamp bulb, and a 6-watt dash bulb, we have a total wattage of 76. If the battery voltage is 12, then, since Current × Volts = Watts, the discharge current should be equal to $\frac{\text{Watts}}{\text{Volts}}$, i.e. $\frac{76}{12} = 6{\cdot}3$ amperes.

A *frequent cause of the ammeter failing to read*, when the engine is working normally, is a *faulty cut-out.* The latter in these cases fails to close the battery circuit when the designed speed is reached. Sometimes a particle of dirt, or a too stiff control spring, is the cause. If the cut-out contact adjustment screw has shaken loose, the adjustment may have altered.

When the cut-out is correctly set, the ammeter should read " zero " with the engine at rest or running slowly (below 12–15 m.p.h. on top gear), and when running above this speed should show a charge of 8 to 14 amperes, depending upon the type of dynamo and its speed for car types. The current should increase with speed up to, say, 30–40 m.p.h., after which —owing to the dynamo current-regulating device—it may fall slightly.

(*c*) **Lights Gradually Diminish in Brightness.**—This is undoubtedly a sign of an exhausted battery.

(*d*) **Lights Glow Too Brilliantly.**—The lights will sometimes glow too brilliantly and occasionally burn out.

The cause may be a blown main or battery fuse, owing to a short circuit, which allows the dynamo to supply the lamps direct. A broken connection in the battery circuit is another cause. The engine should only be run at a low speed if this trouble occurs and the earliest opportunity taken to examine the leads and connections.

In some lighting systems there is often a possibility of the dynamo current regulation failing to operate satisfactorily, thus allowing the current to exceed the correct maximum value for the lamps.

If the excessive-current trouble tends to persist, and it is found not to be due to a broken main fuse or battery connection, the current regulator on the dynamo should be examined, and if there is any doubt an ammeter should be inserted in the output circuit to check the current values at different speeds. The current should increase with engine speed up to 30–40 m.p.h. (top gear) and thereafter either keep constant or fall a little.

(*e*) **Brilliance Varies with Speed of Car.**—If this symptom occurs, it is due to one or other of two chief causes, viz. (1) The battery may be exhausted or the acid level too low. With battery ignition this fault will be evident by the failure of the starting motor or ignition system. With magneto ignition this cause may be verified by switching on the lamps and noting their brilliance.

(2) The battery connection may be broken somewhere, may be dirty, corroded, or loose. The connections between the battery and switchboard should be examined, and if necessary cleaned and tightened.

(*f*) **Lights Flicker.**—The cause of flickering is a loose connection or contact somewhere in the lighting circuit. A loose terminal or bulb holder is the usual explanation. With single-pole lighting systems a frequent trouble is the earth contact. In most cases the earth leads of the lamps are the defaulters. A broken spring in the bayonet connection will cause flicker. *The path of the earth current* is through the bulb holder outer shell, the lamp casing, lamp bracket, and usually the mudguard, or its stay, to the chassis frame. *There must be good metallic connection* between each of these components. What usually happens is that, although good when the car is new, these contacts or connections become rusted up owing to water percolating between the joints, so that the contact surfaces become

FAULT-FINDING TABLE FOR LIGHTING CIRCUITS

LAMPS	INSUFFICIENT ILLUMINATION.	Lamp badly set on bracket. Bulb discoloured through use. Out of focus. Dirty reflector or bulb Battery exhausted.
	LIGHT WHEN SWITCHED ON, BUT GRADUALLY DIMINISHES.	Battery exhausted.
	BRILLIANCE VARIES WITH SPEED OF THE CAR.	Battery exhausted or low level of acid. Battery connection loose or broken.
	LIGHTS FLICKER.	Loose connection. Lamp adapter contacts faulty.
	NO LIGHTS.	Battery exhausted. Broken or loose connections. Lamp filament broken. Broken spring in bayonet connection.

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faulty. with the result that with car vibration the return path of the current is frequently interrupted.

If *flickering of any particular lamp* occurs, the best thing is to disconnect each component and clean the metallic contact surfaces. If the joints thus cleaned and tightened in position are given a coating of paint, this will prevent ingress of water and a recurrence of the trouble. If all the lamps flicker, the faulty connection is in the main battery circuit—usually the battery-frame connection.

(*g*) **Lamps Fail to Light when Switched On.**—If one particular lamp fails to light, the others lighting satisfactorily, the trouble is caused either by a faulty bulb or bulb holder, or a broken lead to the lamp. If all the lamps fail to light, the cause may be due to (1) Exhausted Battery, (2) Blown Fuse, (3) Broken Main Battery Connection, either at the Earth Side or Switchboard, (4) Bad Connections between the Battery, Ammeter, and Switchboard in the case of Two-pole Lighting Circuits.

The fault-finding table above will be found useful in rapidly diagnosing lighting-circuit troubles.

Locating Broken Cables

All that is necessary for the purpose of locating broken leads or cables is to take an ordinary test lamp of the type used for lighting purposes, and connect it in series with the battery and the two ends of the suspected cable, as shown in Fig. 320 (B). Connect the negative wire of the battery with one end of the cable through a suitable test lamp and the positive wire to the other end of the cable or frame.

A voltmeter can be employed equally well; an ordinary flashlamp and dry battery as used in electric hand lamps is also suitable.

If the cable is broken, the lamp will not light up; if sound, the lamp will glow in the usual manner.

For testing purposes, the two ends of the cable should be detached from their connections before testing, although this is not always essential.

Another test for a broken cable is to take a separate length of insulated

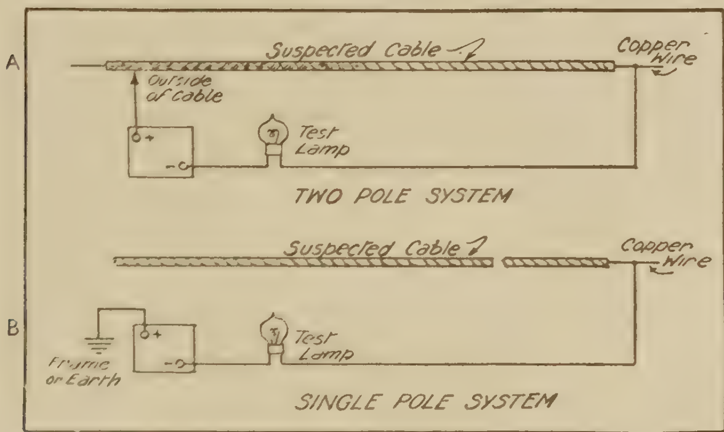


Fig. 320.—Illustrating Methods of Testing for Defective Cables.

cable and attach its ends to the same terminals as those of the suspected cable. If the test lamp then lights, it can be concluded that there is a break in the suspected cable. The same methods can be used for testing for a break in any of the electrical circuits, or to ascertain whether a lamp lead is at fault.

Testing for Short Circuits.—After a fuse has blown the circuits should be tested for "shorts" before replacing the fuse in question. It is very probable that one of the positive leads or wires has short-circuited on to a negative lead, or to earth (in the case of single-pole systems).

Short circuits may be traced by employing a somewhat similar testing arrangement to that used for locating broken cables. Fig. 320 (A) shows a suitable testing arrangement. To test for a short circuit connect the positive end of the battery to the outer covering (if of the armoured metal sheath type) or to the frame of the car, taking care to clean the metal at the connecting place. The other (negative) end of the battery is connected to the test lamp and to the bare wire of the suspected lead. If the lamp lights this indicates that there is a short circuit in the cable in question. *Note* that the switch for the suspected cable circuit should be "off".

Care of the Lamps

Although the head-, side-, and tail-lamps of modern cars seldom give trouble, their efficiency depends to a large extent upon the care and attention bestowed upon them.

Apart from the question of the electric cables and connections the following are the usual items requiring attention:

(1) *Cleaning the Cover Glasses, Bulbs, and Reflectors.*—To obtain the greatest amount of illumination it is necessary to keep these parts clean. In particular, the outer surfaces of the headlamp glasses become dirty owing to mud, insects, or dust, and should be cleaned every time the car is to be used at night.

At intervals the reflector should be polished. As this reflector is usually made of copper, silver-plated, it is necessary to avoid scratching the relatively soft silver coating. One of the silverware cleaning powders (e.g. whiting) or liquids (e.g. Silvo) should be used to remove stains, and the surface afterwards polished with a soft cloth such as Selvyt or clean sponge-cloth. Wadding used with methylated spirit is also another excellent silver-cleaning material.

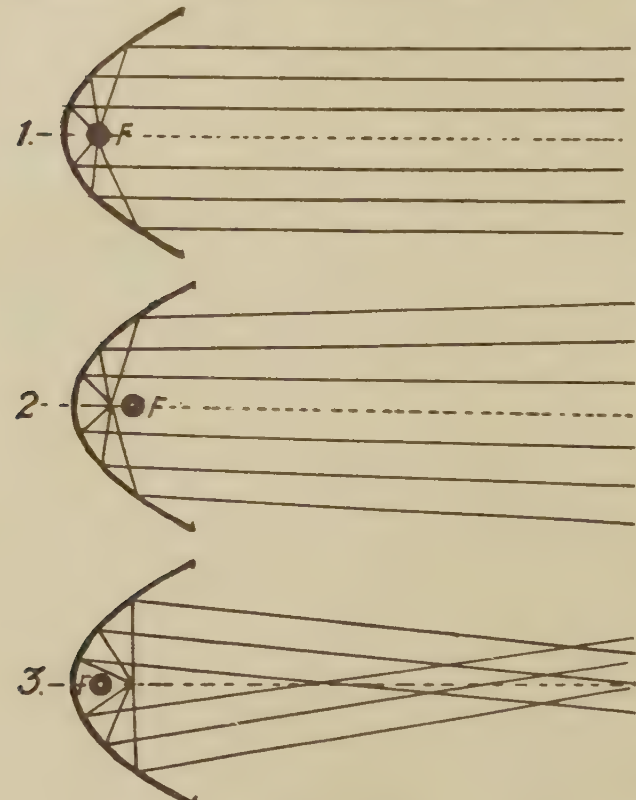


Fig. 321.—Illustrating the Effect of Altering the Position of the Lamp Filament in a Parabolic Reflector.

(2) *Checking the Lamp and Bracket Fixtures.*—After a car has been in service for some time it is advisable to examine the bolts, or screws, holding the lamp brackets to the frame, for these have a habit of working loose, and—in the case of the headlamps especially—altering the directions of the beams. The connections of the lamps on their brackets must also be checked at the same time.

Focusing Headlamp Bulbs

Legal Lighting Requirements.—The Ministry of Transport Lighting Regulations lay down that a motor-vehicle lighting system must be arranged so that it can give a light which must be incapable of dazzling any person standing on the same horizontal plane as the vehicle at a greater distance than 25 ft. from the lamps, the person's eye-level being not less than 3 ft. 6 in. above that plane.

Incorrectly focused and adjusted headlamps are so very frequently met with on the road that an outline of the correct methods of focusing will be given. It should be emphasised that greater comfort in night driving to the driver and other road users can only be secured if the headlamps are correctly focused and directed. Most motor headlamps are fitted *with parabolic-type reflectors*; these possess the property of giving parallel beams of light when the (point source of) light is placed at a given spot F on the axis, known as the focus of the parabola (Fig. 321 (1)). If the light is placed *nearer* to the reflector, the result will be to give a *divergent or spreading beam* (Fig. 321 (2)), and if *farther from the reflector*, a *convergent beam* (Fig. 321 (3)). If these points are understood, the method of correctly focusing headlamps can readily be followed.

There is another important feature of the beam produced by the parabolic reflector, namely that it is not a truly parallel one, owing to the fact that the bulb filament has a definite diameter or thickness. This results in a certain amount of side or diffused light outside the main beam which prevents formation of a parallel or cylrindical beam.

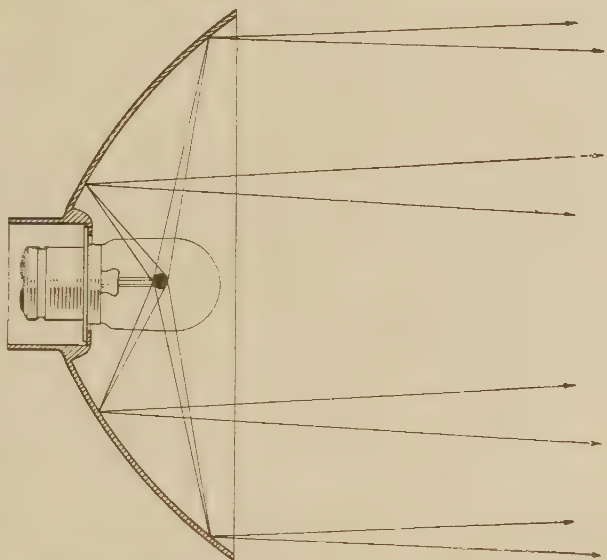


Fig. 322.—Showing Main Beam and Scattered Light due to the Lamp Filament Shape (Lucas).

If the filament is arranged at the centre of the reflector and at its focus, the distribution of the light rays will be as shown in Fig. 322, so that there is one main beam surrounded by an outer, less intense beam.

This feature of the ordinary headlight beam is shown in more detail in Fig. 323. The net result of this light dispersion is that it is not possible to arrange for a clean cut-off of the light from a headlamp even when the axis is tilted a little downwards. As will be explained later, it is now possible to overcome the dazzle effect of the beam and to improve upon the popular "dip-and-switch" system that has been so widely used in this country.

Unless the focus of the bulb in the reflector is correct, quite half the available light may be lost. A correct focus is secured by screwing the bulb backward or forward. A slight movement makes a relatively big difference in the shape and character of the beam, and the variation in position of the filament in one bulb and another will have the same effect; therefore, when replacing a bulb, see that it focuses correctly.

The usual headlamp adjustment method is as follows:

(1) With the rear seat of the car fully loaded, car should be placed on a level driveway in such a position that the fronts of the headlamps are 25 ft. from a smooth vertical surface—such as a wall or garage door—pre-

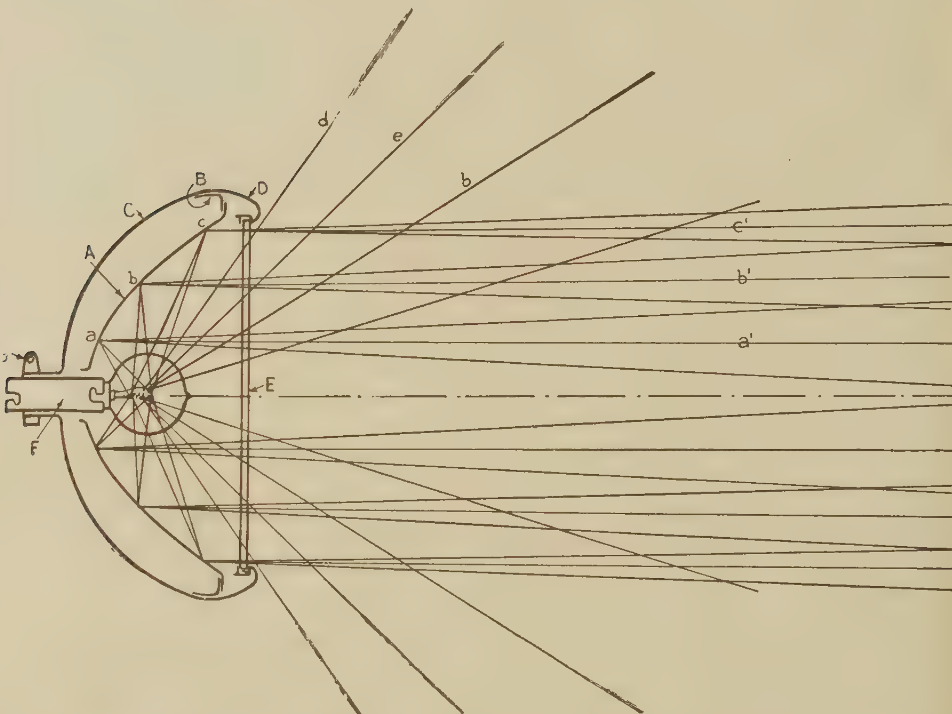


Fig. 323.—Illustrating the Optics of the Ordinary Parabolic Lamp.
A, Reflector. B, Reflector Support. C, Lamp Casing. D, Front Glass Support. E, Front Glass. F, Lamp-bulb Holder. G, Clamp for F.
a, *b*, and *c* show direct and reflected light rays, and *a′*, *b′*, and *c′* scattered light ray pencils.
d, *e*, *b* (above) show non-reflected, or direct rays from the lamp filament, which give side illumination.

ferably of light colour. The centre line of car should be at right angles to surface of wall or door.

(2) Measure the distance from the ground to the headlamp bulb and mark a horizontal line on the wall or door at this height.

(3) Switch on the lights to the bright or driving position and cover up the beam from one lamp while the other is being adjusted. Adjust the focusing device on the back of the lamp until the beam produces the brightest vertical patch of light on the surface of the wall or door—25 ft. away. The two light patches should be separated by a distance equal to that of the headlamps.

(4) Loosen the lamp mounting nuts slightly and tip the lamp up or down until the top cut-off of the light pattern comes just below the horizontal line on the wall. Place a straight-edge across the fronts of both lamps and see that lamps are so adjusted that both bear flat against the straight-edge. Then see that nuts are tightened. It is advisable to again notice the pattern of the light on the wall to be sure that it has not been changed during the tightening process of the lamp-mounting nuts.

Aligning and Focusing Lucas Lamps

The following is the recommended procedure for aligning and focusing the ordinary model Lucas lamps. In this respect it should be pointed out that two things are essential, viz.:

(1) The lamps must be aligned so that they direct the beams straight ahead, i.e. parallel with the road and also with each other and the central axis of the car (Fig. 324).

(2) The bulbs fitted should be the Lucas type recommended for the particular lamps; these suit the optical properties of the Lucas reflectors.

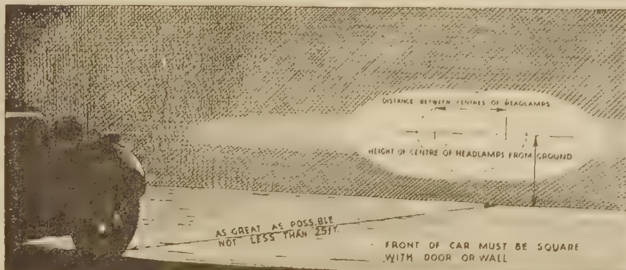


Fig. 324.—Aligning Lucas Headlamps.

Checking the Alignment.—The simplest way of checking the adjustment of the lamps is to take the car on a straight, level stretch of road at night and examine the direction of the beams. Are they parallel with the road and with each other? If one appears to be out of alignment, adjust as follows: Slacken the single fixing nut at the base of the lamp, and move the lamp on its universal mounting to the required position, finally locking the adjustment by tightening the fixing.

Focusing.—For the lamps to give a parallel beam, the filament of the bulb must be as near as possible to the focus of the reflector. If the filament of the bulb is behind the focal point of the reflector, the beam will be divergent, while on the other hand, if the filament is in front of the focal point, the beam will be convergent, with a dark area in the centre of the beam. In either case, after each adjustment, note the effect with the reflector and front refitted.

When the best position for the bulb holder has been found, see that the clamping screw is tightened. With some types, alternative locations are provided for the bulb in its holder. Try each position for the best result.

If you can park your car on a flat space in front of a garage door or a

wall so that the headlamps are at least 25 ft. away, then the aligning and focusing can be very easily carried out without taking the car on the road.

It is essential that the car is square with the door or wall. The lamps should be aligned so that the horizontal axis of the oval light area is level with the centres of the lamps. The vertical axis should, of course, be central with the front of the car.

The headlamps fitted to the Vauxhall "Velox" and "Wyvern" cars are aligned and focused as follows:

First remove the headlamp rim by unscrewing the securing screw at the bottom. Remove the rubber sealing ring, thus exposing the three headlamp beam trim screws, which are shown in the lower diagram in Fig. 325.

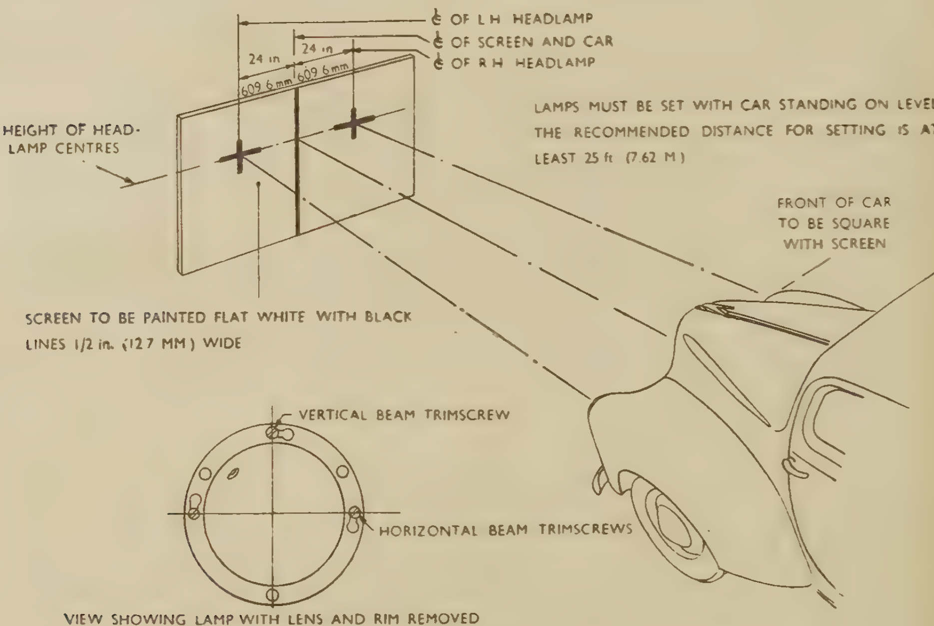


Fig. 325.—Method of Adjusting and Aligning the Vauxhall Headlamps.

The lamps should be at least 25 ft. from a vertical wall or screen, the car being horizontal. The complete alignment instructions are given in Fig. 325, it being necessary only to add that the heights of the black crosses on the screen should be the same as that of the centres of the headlamps from the ground.

The various components of the Vauxhall headlamp are shown in Fig. 326 and described in the caption below.

The headlamp is attached to the wing of the car by means of three screws, a rubber gasket being used for weather-sealing purposes.

When the vehicle is given a complete overhaul the lamps should be inspected for damage to the reflector, soundness of the lamp bulbs, abrasion

of the cables, deterioration of the rubber gasket, and operation of the beam trim screws.

The Lucas Beam Setter.—For garage and routine headlamp alignment and focusing purposes, it is more accurate and quicker to employ an optical instrument, such as the Lucas Beam Setter illustrated in Fig. 327. It obviates tests after dark (with the vehicle placed at not less than 25 ft. from a wall or screen), as the instrument is placed close up to the headlamp, as shown in Fig. 328, so the tests can be carried out in daylight.

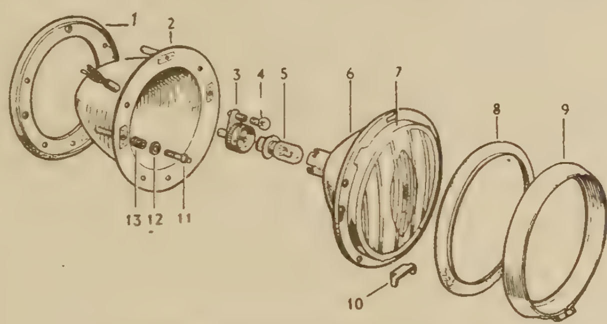


Fig. 326.—Showing Details of the Vauxhall "Velox" and "Wyvern" Headlamps.

1, Rubber Seal—Headlamp Body to Wing. 2, Headlamp Body. 3, Adapter—Headlamp Bulb. 4, Pilot Bulb. 5, Headlamp Main Bulb. 6, Reflector Assembly. 7, Clamp Ring—Reflector to Headlamp Body. 8, Rubber Seal—Headlamp Rim. 9, Headlamp Rim. 10, Fixing Clip—Reflector Clamp Ring. 11, Special Screw—Clamp Ring to Headlamp Body. 12, Flat Washer. 13, Spring.

The principal unit is a cylindrical optical tube (Fig. 327), which is mounted on a robust carrier having rubber wheels. The carrier has two vertical tubular guides up and down which it can slide, and a counterweight system giving easy movement and ensuring that the tube does not

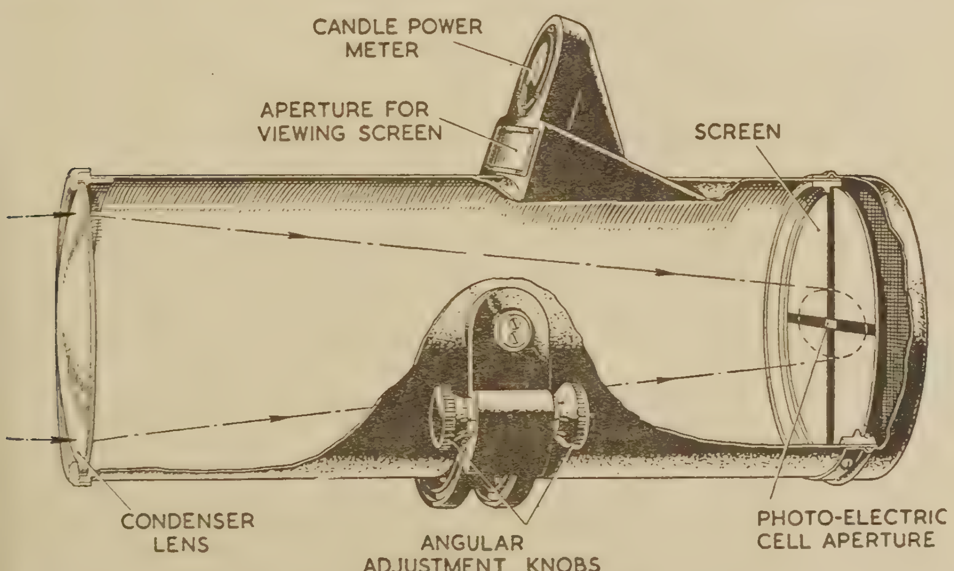


Fig. 327.—The Lucas Beam-setting Device.

move after reaching its correct vertical position. The stand also has two horizontal tubular members at right angles to the vertical guides along which the mounting for the latter, together with the optical tube, can slide; this movement is for lateral adjustment of the tube. Handles are provided for raising and lowering the tube and for traversing adjustments. A further movement is provided to give angular movement to the optical tube.

The optical system (Fig. 327) consists of a tube having a plano-convex lens at one end for condensing or reducing the optical beam from the headlamp to a screen at the farther end of the tube, as shown by the arrowed light-ray lines, so as to form a reduced image on the screen. At

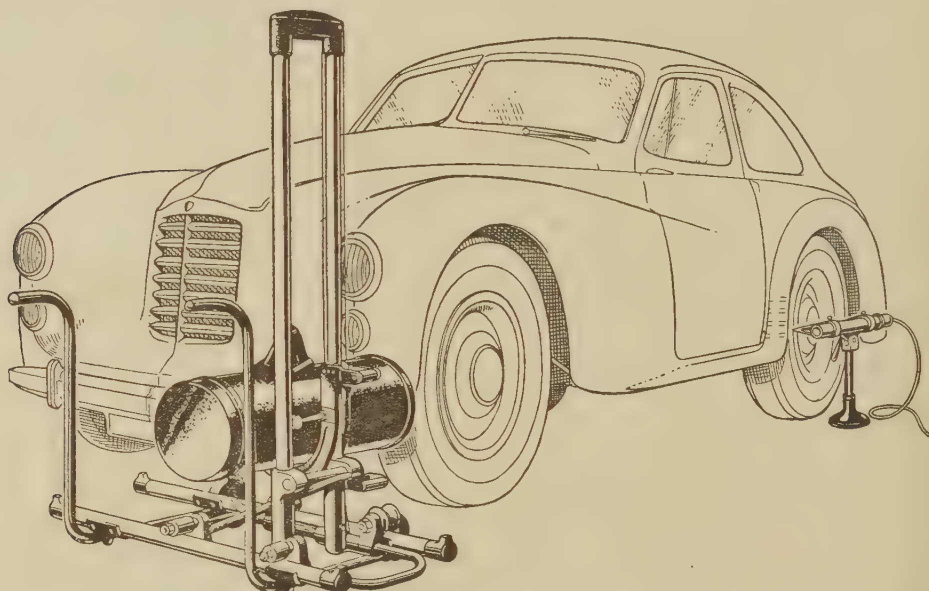


Fig. 328.—Showing Method of Using Lucas Beam Setter.

the centre of the latter a photo-electric cell is mounted behind an aperture. This is connected by leads to a candle-power meter on top of the tube above an aperture which is arranged for viewing the screen. The photo-electric cell and meter measure the intensity of the light focused on the screen. Adjustments are made to the headlamp *until the position of maximum candle-power* is obtained. This position is the correct setting for the lamp.

In order to set the lamp beam with respect to the longitudinal axis of the vehicle, provision is made, by the use of a separate aligning tube and auxiliary screen, to align the optical tube correctly.

The aligning tube (Fig. 329) consists of a reflector, bulb, and lens which are housed in a tube having horizontal feeler arms for making contact with the rear wheel rim of the vehicle. The tube throws an image in the shape of a cross on an auxiliary screen. The latter is then removed

and the optical tube adjusted until the image of the cross is projected on its screen as seen through the viewing aperture. The axis of the optical tube is then parallel to the axis of the vehicle, and the tube can be adjusted upwards and sideways to its testing position over the headlamp.

The manufacturers issue detailed instructions for carrying out the align-

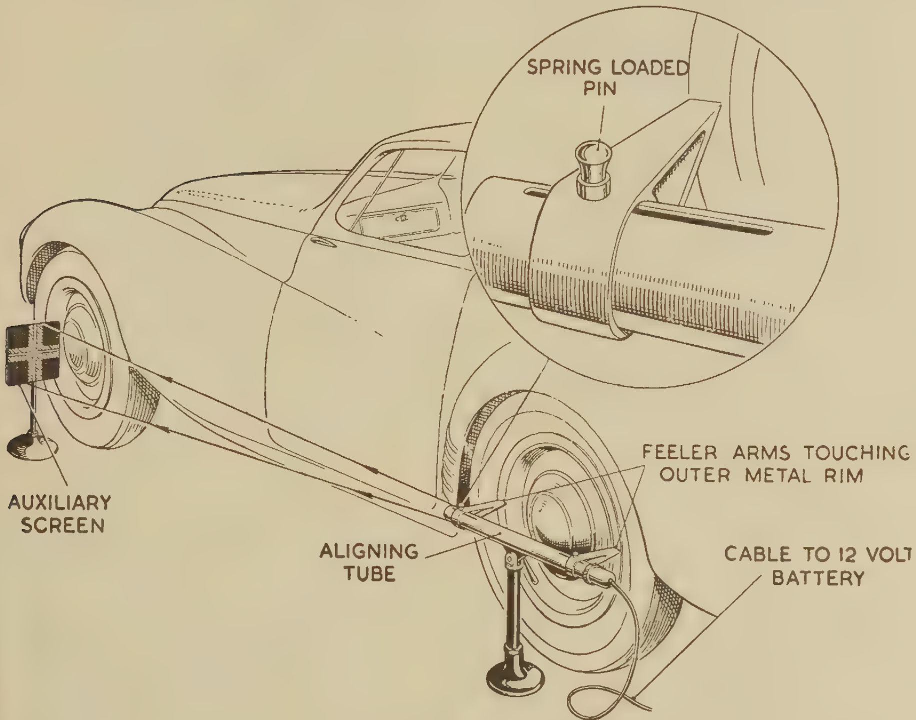


Fig. 329.—The Longitudinal Aligning Device.

ment and beam-focusing tests upon headlamps. If the lamps have pre-focus bulbs they can be aligned forthwith, but for lamps with focusing bulbs it is necessary to focus them correctly before beam setting (or aligning) tests can be carried out. The optical tube is used for the focusing operation.

Non-glare Lamps

Fig. 330 illustrates a good method of adjusting *non-glare* headlamps of American pattern. The headlamps should be so adjusted as to concentrate the light from each lamp in a shallow beam or ray, thus spreading it sideways over the road surface and directing it straight ahead; adjusted in this manner the top of the light ray is slightly below the horizontal and glare is minimised.

Before attempting to adjust the headlamps first make certain the stripes or cylindrical zones in the reflectors are vertical.

Two adjustments are provided: The body of each lamp can be tilted up or down or to the right or left merely by loosening the headlamp-bolt

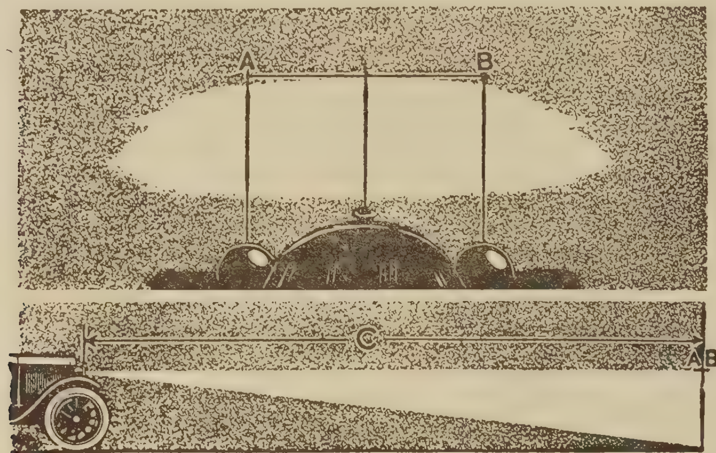


Fig. 330.—Adjusting Non-glare Headlamps.

nut. The lamp bulb can be pushed forward away from the reflector or backward towards it by loosening the focusing screw on the outside of the headlamp body. *It must be borne in mind that the lamp bulbs should be focused only after the lenses and the headlamp rims have been installed.*

Fig. 330 illustrates an excellent method to follow in making these adjustments. Place the car on a level surface, 25 ft. from a wall or a side of a building—preferably white—and adjust each lamp as described above, keeping the lamp not under adjustment covered; in other words, each lamp is individually adjusted. The top of the light beam, when the adjustment is correct, should fall on the wall as illustrated by the horizontal line A–B in Fig. 330 at a point equal to the height of the centres of the headlamps above the floor or ground, *with the car loaded.*

Lucas Lamp Adjustments

Various designs of Lucas headlamps have been in use for many years. Of the more widely used recent types there are two methods employed for focusing the filament of the bulb, namely: (1) the sliding bulb-holder and (2) the stepped bulb-holder.

The sliding bulb-holder method consists in making the cylindrical brass exterior bulb holder to slide in a slotted tube member affixed to the reflector unit. Focusing is done by slackening the clamping clip screw with a screw-driver, as shown in the left-hand illustration of Fig. 331. The bulb

is now moved axially in the tube until correctly focused, after which the clamping screw is tightened.

The stepped bulb-holder method, illustrated on the right in Fig. 331 and

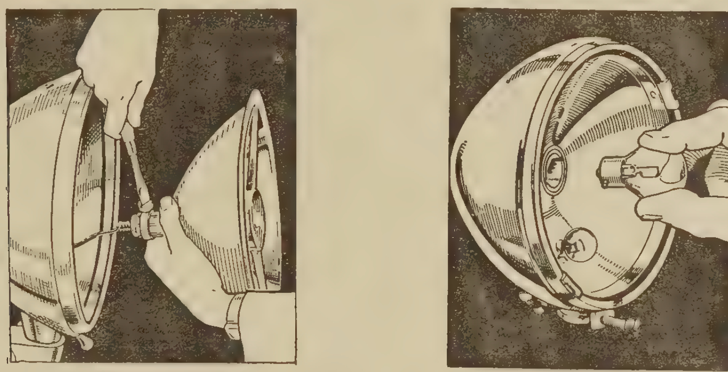


Fig. 331.—(Left) Method of Focusing Sliding Bulb-holder Lamp. (Right) The Alternative Bulb-holder Location-type Lamp.

in detail in Fig. 332, depends upon the pins of the lamp bulb base being placed in the correct one of three steps made in the slotted bulb holder.

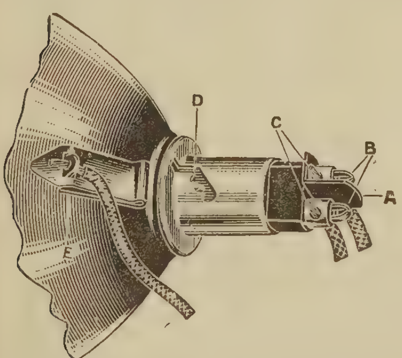


Fig. 332.—Showing Focusing Notches (D) and Cable Connections of Lucas Headlamp.

A, Black Insulating Piece.
B, Contact Pieces.
C, Terminal Holes.
D, Focusing Notches.
E, Spring terminal for "return cable" when the lamp is fitted with a double-filament bulb.

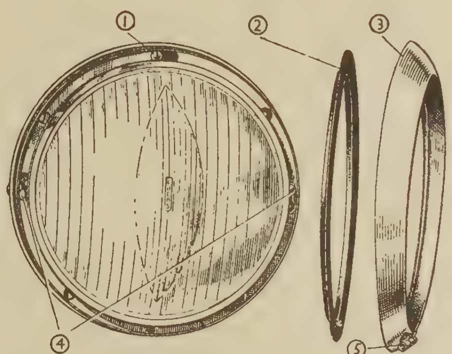


Fig. 333.—The Lucas Headlamp (Austin A40).

1. Vertical Adjusting Screw. 2. Rubber Ring. 3. Front Rim. 4. Horizontal Adjusting Screws. 5. Rim Securing Screw.

There is no necessity for clamping clips, as the ordinary contact clips on the fixed outer tube unit hold the bulb firmly in position.

To remove the reflectors of these lamps it should be remembered that the fronts and reflectors of the lamps are locked in their bayonet slots by a patented

arrangement of locking springs. To remove the front of the lamp, press the front rim evenly and then rotate to the left (looking at the front of the lamp) as far as possible, when the front may be easily withdrawn.

It is only necessary to remove the reflector for the purpose of connecting or disconnecting the cables from the terminals. To do this, press the reflector rim evenly and turn to the left, when the studs will disengage themselves from the slots in the body of the lamp. When refitting the reflector place it so that all the studs engage together in their respective slots, then turn it to the right until it comes against its stops. The word " TOP " which is stamped on the reflector should then be at the top of the lamp and opposite to the medallion. The instructions for replacing the front are stamped on the rim of the reflector.

Pre-focused Headlamps

The more recent headlamps employ bulbs having special " pre-focus " caps, such that when the bulb and its cap are inserted in the reflector the filament is exactly in focus. No focusing of the bulb is necessary throughout its useful life. The pre-focus cap is located accurately in the reflector, and secured by a bayonet back-shell, which also provides contact for the bulbs.

Some Lucas headlamps of the post-war years incorporate pilot bulbs, but separate sidelamps are usually fitted for legal requirement purposes, including parking the car at night.

American headlamps employ what is known as the " *sealed-beam* " units, each of which comprises the filaments, reflector, and lens completely sealed together. The glass reflector is sprayed inside with vaporised aluminium, which gives a superior reflecting surface to that of silver. The unit has two filaments, the upper for the main headlamp beam and the lower for passing purposes. The lens is fused to the glass reflector and the interior is filled with a special inert gas. Should either filament fail in service, a complete new sealed beam unit must be used to replace the faulty one.

Should a headlamp fail it is an easy matter to check the sealed-beam unit by replacing with a sound one; or by using a 6-volt test bulb and clips. The American headlamp has two screws (Fig. 334) for aligning the beam horizontally and vertically.

To replace a sealed-beam unit, remove the cover glass (outer rim) screw and then the glass. Then loosen the retainer-ring screws and turn and then remove the retaining ring. Lift out the sealed-beam unit and pull off the connector.

Removing Lucas Pre-focus Bulb.—The procedure for removal of the light unit is as follows:

Remove the front rim by unscrewing the rim-securing screw and lifting off the rim, which is split to facilitate removal. Next remove the dust-excluding rubber, when three spring-loaded adjustment screws will be visible (Fig. 335). Press the light unit in against the tension of the adjust-

ment screw springs and turn it in an anticlockwise direction until the heads of the screws can be disengaged through the slotted holes in the light unit rim. Do not disturb the screws when removing the light unit, as this will alter the lamp setting.

Twist the back-shell in an anti-clockwise direction and pull it off. The bulb can then be removed.

Place the replacement bulb in the holder, taking care to locate it correctly.

Engage the projections on the inside of the back-shell with the slots in the holder, press on, and secure by twisting it to the right.

Position the light unit so that the heads of the adjusting screws protrude through the slotted holes in the flange, press the unit in and turn in a clockwise direction. Replace the dust-excluding rubber so that its thicker inner edge rests in the recess around the light unit rim. Refit the front rim, locating the top of the rim first and securing by means of the fixing screw.

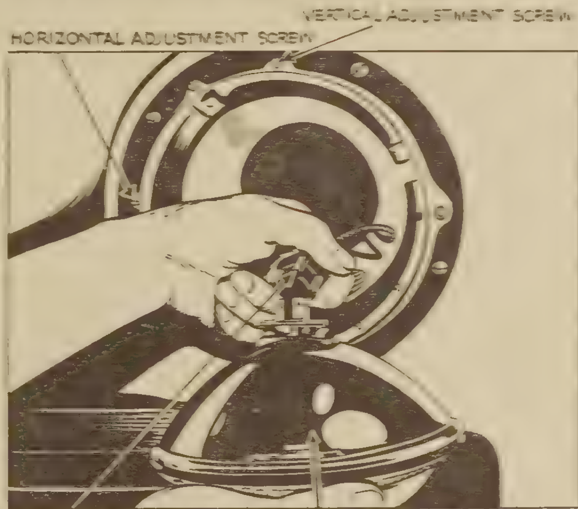


Fig. 334.—Replacing Headlight Sealed Beam Unit (Kaiser-Frazer).

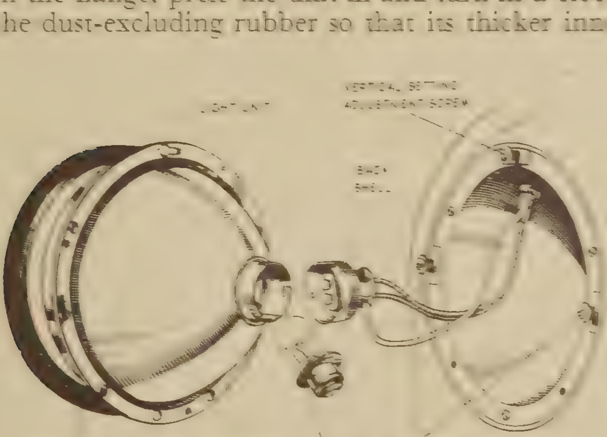


Fig. 335.—The Lucas Flush-fitting Headlamp, Mark I

Lucas Flush-fitting Marks I to III Headlamps.—To remove a light unit, take off the front rim and dust-excluding rubber. Press the light unit in against the tension of the adjustment screw springs and turn it in an anti-clockwise direction until the heads of the screws can be disengaged through the slotted holes in the light-unit rim. Do not disturb the screws when removing the light unit or the lamp setting will be changed.

In all headlamp cases the bulb is made accessible by removal of the back-shell. To do this twist the latter anti-clockwise and pull it off. The bulb can then be removed from the rear of reflector when the spring-securing clip is released.

Some double-filament bulbs may be fitted in either of the two positions in the holder. If the bulb has the marking " top " on the metal cap, however, care must be taken to fit it accordingly, or the " main " and " dip " beams will become interchanged. The more recent bulbs have a special cap, and can only be fitted in the correct position.

Replacing Light Units in Different Lamps.—There are three different Lucas headlamps, and the instructions for replacing the light units and front rims are as follows:

External Lamps.—Engage the side of the rim opposite to the fixing device with the lamp body, press on, and secure with the fixing device. On some lamps a metal tongue on the inside of the front rim must be engaged with a slot in the lamp body.

Flush-fitting Lamps, Mark I.—Position the light unit in the lamp body so that the vertical trim adjusting screw locates in the slot in the body rim, and the heads of the two fixing screws protrude through the slotted holes in the flange of the light unit. Twist the light unit in a clockwise direction and secure by tightening the two screws. Locate the top of the rim first, press on at the bottom, and secure by means of the fixing catch.

Flush-fitting Lamps, Marks II and III.—Position the light unit so that the heads of the adjusting screws protrude through the slotted holes in the flange, press the unit in and turn in a clockwise direction. Replace the rubber ring so that the thicker inner edge rests in the recess around the light-unit rim. Refit the front rim, locating the top of the rim first, and securing by means of the fixing screw.

Lucas "Dip-and-Switch" Headlamp

In view of the large number of these lamps now in use the following information on their dismantling, for cleaning and bulb-replacement purposes, will be found helpful.

The fronts of most types of headlamps are secured by means of a screw B (Fig. 336) or a spring catch. To remove the front, slacken the screw and swing it aside from the slot C. The front can then be removed. When replacing the front, locate the top first, then press on the rim at the bottom of the lamp. With some lamps, the reflector is fixed to the lamp front and the bulb holder is secured to the reflector by means of a spring fixing. To remove the bulb holder, press down the ends of the securing spring and withdraw them from the slots in which they locate.

The method of removing the sidelamp fronts is similar to that for the headlamps.

Right-hand-drive Lamps.—In countries where the rule of the road is

right-hand (instead of left-hand, as in the United Kingdom), the dipping reflector can be arranged to dip vertically or to the right.

Reflectors which are located to the body by a screw at the top of the reflector rim have an alternative screw-hole for use when the reflector is required to dip vertically.

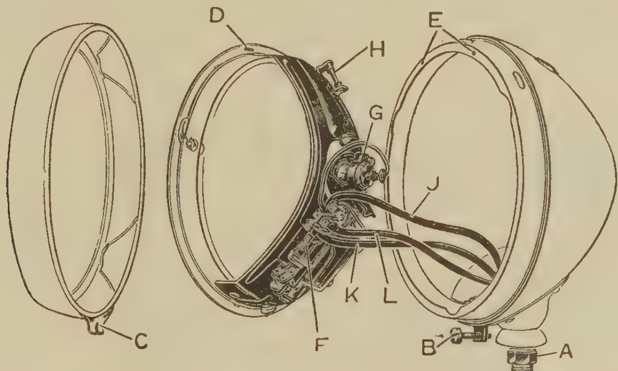


Fig. 336.—A Typical Lucas Headlamp with "Dip-and-Switch" Reflector (shown dismantled).

A, Locking Nut for Adjustable Mounting.
B, Front Fixing Screw.
C, Slot.
D, Reflector Fixing Screw.
E, Alternative Locations for Reflector Fixing Screw.
F, Fuse.
G, Clamping Clip for Focusing Adjustment.
H, Spare Fuse.
J, Cable to Distribution Box or Switchbox.
K, Cable to Off-side Lamp.
L, Cable to Dipper Switch.

With the type of reflector located on three supports, fitting the reflector so that the slot marked " R " engages with the top support causes it to dip to the right.

If cars fitted with " dip-and-switch " reflectors are to be used for any length of time in countries where the rule of the road is right-hand, it is advisable to interchange the headlamp reflectors. This involves slight modifications to the wiring.

The Fuse in Dipping-reflector Lamps.—The Lucas " Dip-and-Switch " reflector lamps are protected by means of a fuse which is incorporated at the back of the reflector together with a spare fuse. The indication of this fuse blowing will be the failure of the dipping reflector to function (Fig. 337). The cause of the trouble may be a faulty connection inside the lamp, or it is possible that the cables may be fouling the reflector. The reflector can be rocked by the fingers without damage to the highly polished surface (any finger marks can easily be removed with a soft dry cloth). It is thus possible by rocking the reflector with the fingers to see if it is working freely. If it seems stiff, apply the slightest smear of thin machine oil to the moving plunger of the dipper unit and to the bearings on which the reflector rocks.

Other fuses are incorporated in the combined cut-out and fuse box mounted on the engine side of the dash.

The Dip Filament Headlamp

Instead of using a dipping reflector with its relatively complex operating mechanism, a double-filament bulb can be used. In this case there is a main filament at the focus of the reflector and an upper or offset dip

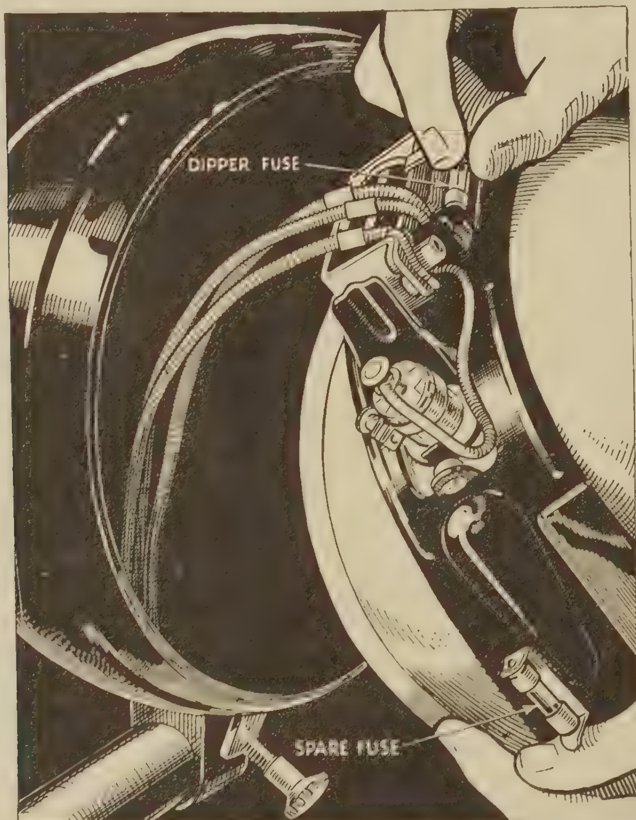


Fig. 337.—Showing Method ot Replacing Fuse in Lucas Dipping-reflector Lamp.

filament. When the headlamp is used for normal purposes only the main filament is used, but when the driver wishes to avoid dazzling the oncoming traffic he uses a switch which switches off the main filament and, at the same time, switches on the offset or dip filament; the latter gives a downward beam.

Referring to Fig. 338, which shows the principle of the Lucas dip filament lamp, the spreading upwards of the light from the dipped beam

is prevented by the use of a special cover glass or " lens " having prism members at the top and bottom; these are moulded in the cover glass. The effect of the prism is to refract or bend the light rays downwards in the manner shown in Fig. 338.

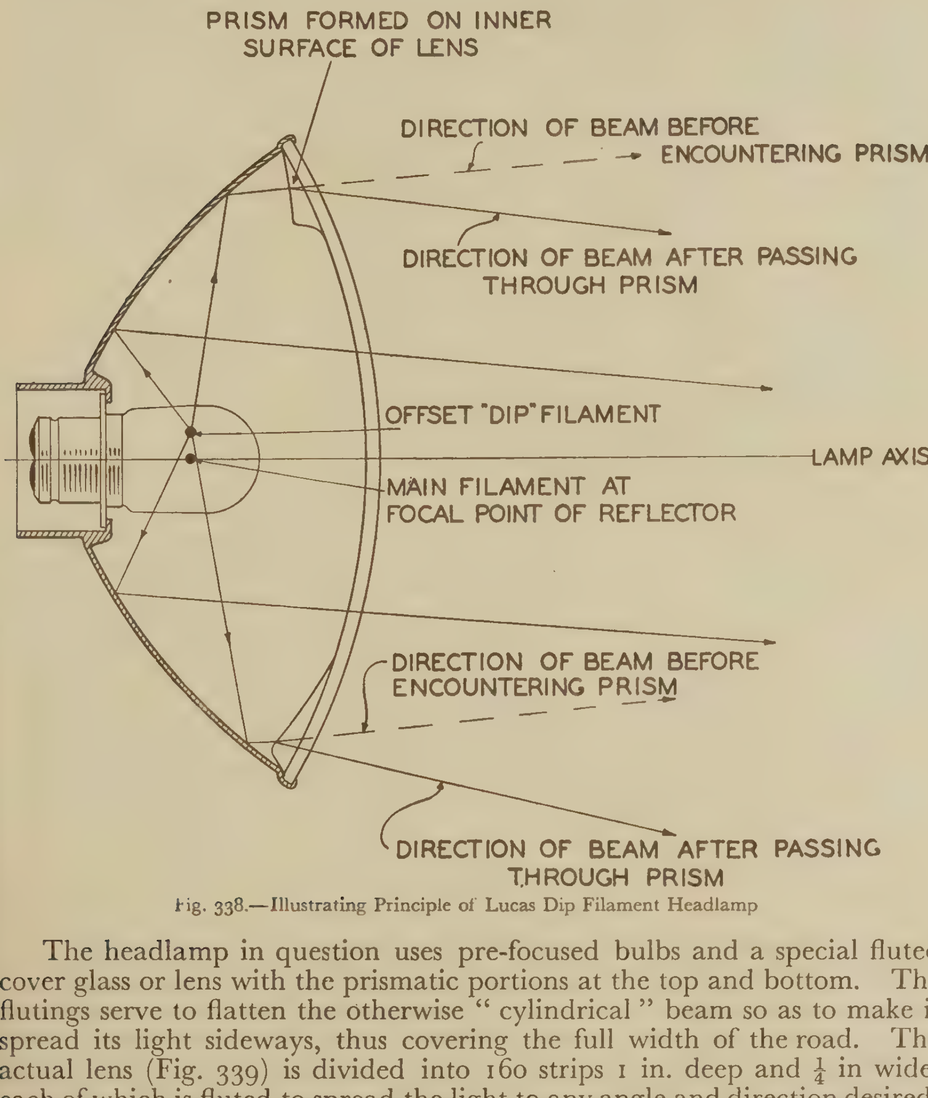


Fig. 338.—Illustrating Principle of Lucas Dip Filament Headlamp

The headlamp in question uses pre-focused bulbs and a special fluted cover glass or lens with the prismatic portions at the top and bottom. The flutings serve to flatten the otherwise " cylindrical " beam so as to make it spread its light sideways, thus covering the full width of the road. The actual lens (Fig. 339) is divided into 160 strips 1 in. deep and $\frac{1}{4}$ in wide, each of which is fluted to spread the light to any angle and direction desired.

The dip filament bulb is now *used in both headlamps*, so that instead of switching off the off-side lamp and dipping the near-side one, the later practice is merely to switch over from " main " to " dip " filament, when downwardly deflected beams from *both headlamps* are used. Thus a much

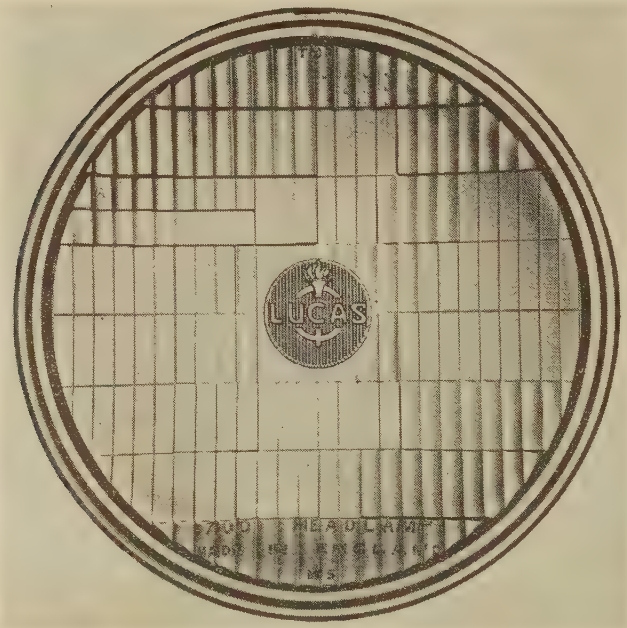


Fig. 339.—Special Cover Glass used on Lucas Dip Filament Lamp.

greater road illumination is obtained without any dazzle effects to the oncoming traffic. With the double-dipping system not only are the beams deflected downwards when the dipping switch is used but, owing to the special square fluting on the inside of the lens, the beam is also diverted to the left.

Cleaning Headlamps

The reflectors are protected by a transparent and colourless covering, which enables any accidental finger marks to be removed with chamois leather or a soft cloth without affecting the surface of the reflector. Do not use metal polishes on Lucas reflectors. Ebony-black lamps can be cleaned with a good car polish. Chromium-plated lamps will not tarnish and only need wiping over with a damp cloth to remove dust or dirt.

Unless the front cover glasses are kept clean the intensity of the light beam may be reduced appreciably. It is important, therefore, to remove surface dirt caused by dust, mud splashes, and—in the summer—dead insect markings.

Lamp-bulb Ratings

The bulbs used in motor vehicles are of different ratings or candle-power, and it is important always to replace a burnt-out bulb by one of similar design and rating. Since the candle-power is proportional to the watts (or energy) consumed, it is usual to specify lamp bulbs by their voltage and wattage. If the wattage is known, the current taken by each lamp can readily be ascertained by dividing this wattage by the battery voltage. Thus a 6-volt bulb of 36 watts as used for headlamps would consume $\frac{36}{6}$, or 6 amperes.

The following table shows the ratings of the various lamps used on the Austin A40:

	Volts	*Watts*	*Lucas No.*
Headlamps:			
Home Models:			
Main (L.H.)	12	36/36	167
,, (R.H.)	12	36	167
Side Pilot	12	6	989
Sidelamps	12	6	989
Export Models:			
Main	12	36/36	167
Side Pilot	12	6	989
Sidelamps	12	6	989
Stop and Tail Lamps	12	24/6	189
Number Plate Illumination Lamp	12	6	989
Ignition and Radio Warning Lights	12	2·2	987
Direction Indicators	12	3	256

Commercial-vehicle Headlamps

In general these employ similar optical and focusing systems to those used on motor-cars, but they are of more robust construction. In some instances the lamps are of the dipping, near-side reflecting pattern; in others the headlamps have twin-filament bulbs. The main filament is at the centre of the bulb and the other above it. When the latter filament is switched on by the dipper switch operation the beam is dipped so as to give a non-dazzle beam. Fig. 341 shows the headlamp in exploded view as used on Bedford vehicles. It has a spherical mounting, so that it can be swivelled and locked in any direction. The bulb is of the two-filament pattern. Focusing of the main beam with the central filament switched on is effected by means of the focusing screw (1) shown in Fig. 341. For this purpose the headlamps should be set so that the driving beams are parallel to the road and pointing straight ahead. When using the focusing screw it should be remembered that *to bring the bulb closer to the reflector the screw is turned clockwise.*

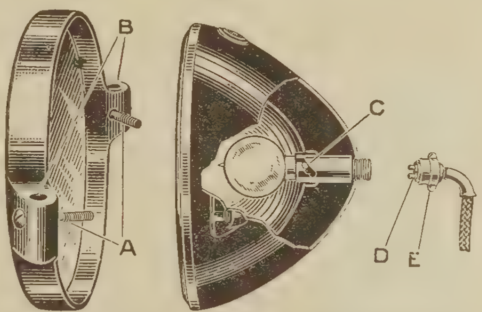


Fig. 340.—Commercial Headlamp Adjustments. Lucas, Type C50.

A, Coin-slotted screws which secure the front to the body of the lamp.
B, Round sockets to fit standard brackets.
C, Focusing notches.
D, Cable plug.
E, Coupling nut.

Fig. 342 illustrates the Simms Type 6301 headlamp, which is of the flush-fitting pattern, for commercial vehicles; it is used on certain well-known vehicles. It has an anodised aluminium reflector which can be adjusted to tilt through an angle of 8° on either side of the vertical axis, and also through 8° on either side of the horizontal axis.

These adjustments for the headlight-beam direction are made by

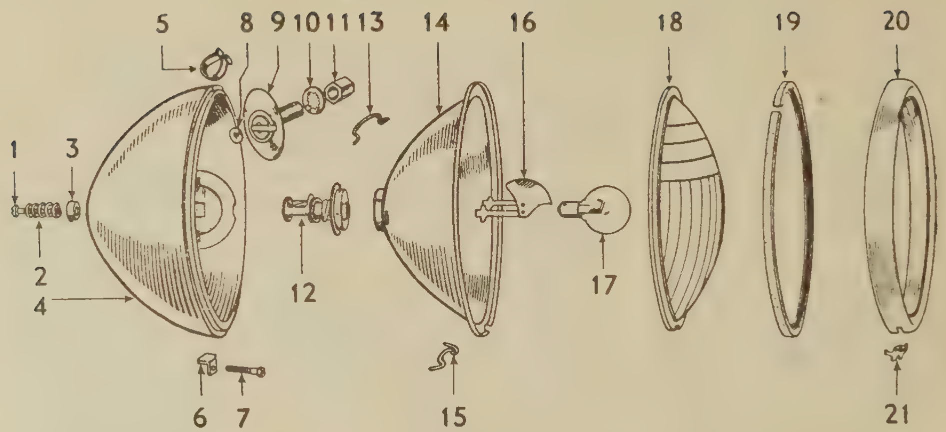


Fig. 341.—C.A.V. Headlamp in Exploded View (Bedford Vehicles).

1, Focusing Screw. 2, Spring—Focusing Screw. 3, Cup—Focusing Spring. 4, Body. 5, Spring Clip—Headlamp Rim. 6, Tapped Plate—Headlamp Rim. 7, Screw—Headlamp Rim. 8, Retaining Washer—Headlamp Wire. 9, Fixing Bolt Assembly—Headlamp. 10, Lockwasher—Headlamp Fixing Nut. 11, Nut—Headlamp Fixing Bolt. 12, Bulb Holder Assembly. 13, Retainer—Headlamp Bulb Shield. 14, Reflector Assembly. 15, Spring—Headlamp Glass Retainer. 16, Shield—Headlamp Bulb. 17, Bulb. 18, Glass. 19, Gasket—Headlamp Rim. 20, Rim. 21, Clip—Headlamp Rim.

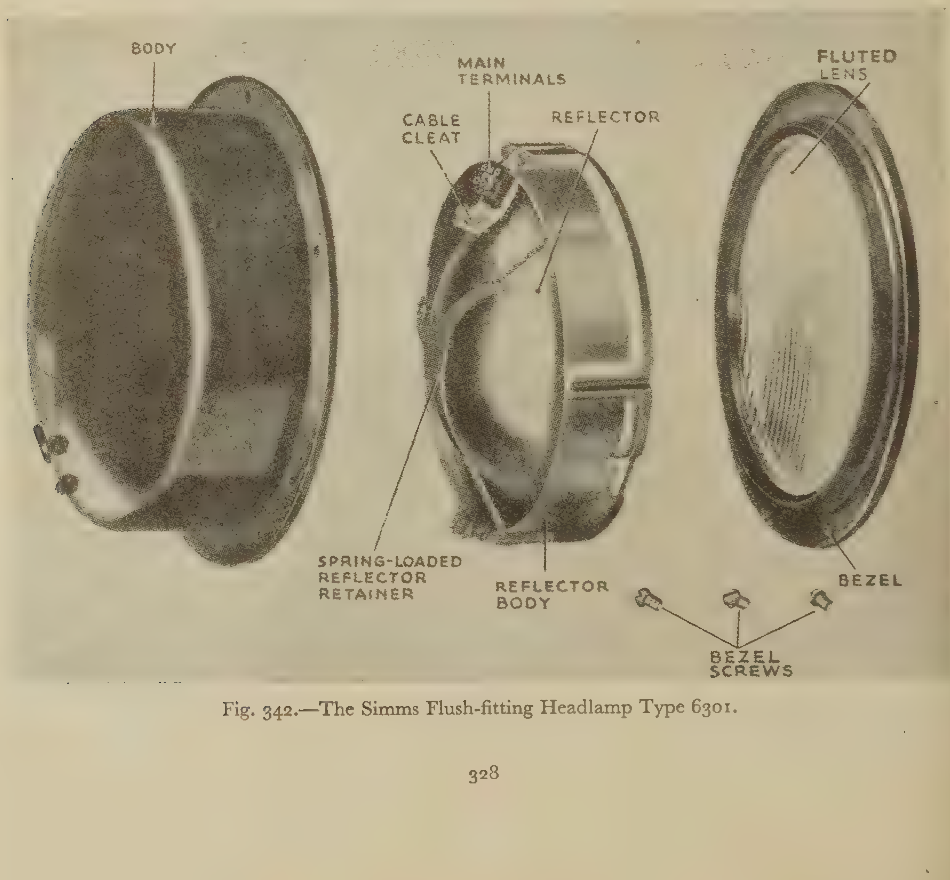
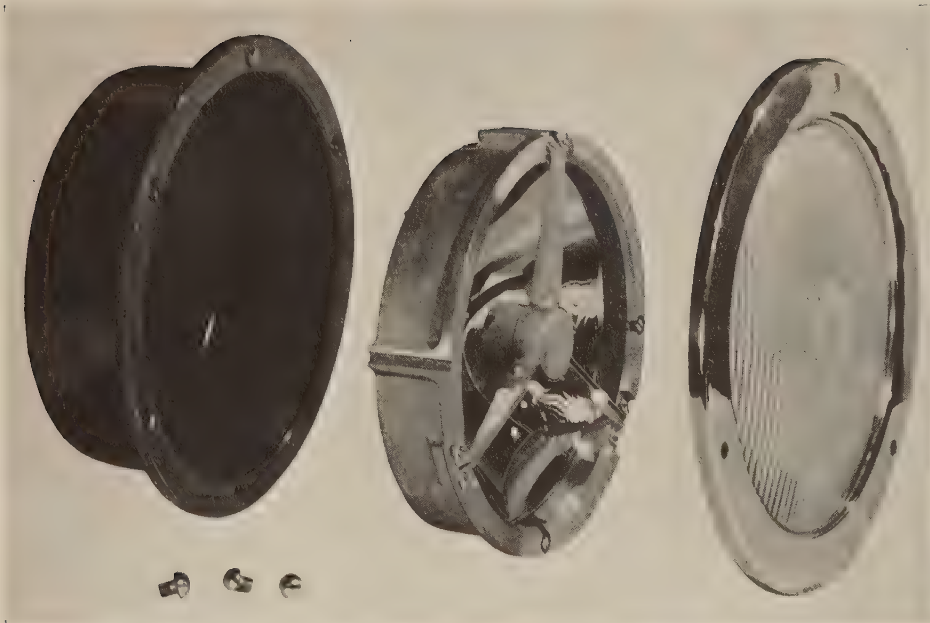


Fig. 342.—The Simms Flush-fitting Headlamp Type 6301.



COMPONENTS OF THE SIMMS COMMERCIAL-VEHICLE HEADLAMP, SHOWING REFLECTOR ASSEMBLY AND BEZEL REMOVED FROM BODY OF LAMP. (TYPE 6300.)

ILLUSTRATING REFLECTOR ADJUSTING SCREWS ON SIMMS COMMERCIAL-VEHICLE HEADLAMP. (TYPE 6300.)

turning the two bezel screws, which are accessible on removal of the bezel, so that the beam direction can be adjusted vertically and horizontally to a fine degree (Plate facing page 328). The bulb holder is fully insulated and is suitable for double-filament bulbs with either small bayonet or flange-type prefocus caps; provision is made for initial focusing. The lamp cover or lens has tapered flutes which provide for even road illumination.

Bulb Replacement.—Remove the three domed bezel screws and lift off the bezel. Insert the hand behind the cross-bar and withdraw the bulb with a bayonet motion, replacing the new bulb in the same manner. If preferred, the knurled clamp nuts on the cross-bar may be loosened and the bulb-holder assembly completely withdrawn. In either case the new bulb must be focused by projecting the beam on to a vertical surface at a distance of approximately 30 ft. and sliding the bulb-holder assembly in the cross-bar until the beam is of minimum diameter. Lock up the knurled nuts again and replace the bezel. Spring washers are not necessary under the bezel retaining screws, for the nuts fixed to the body are the self-locking type.

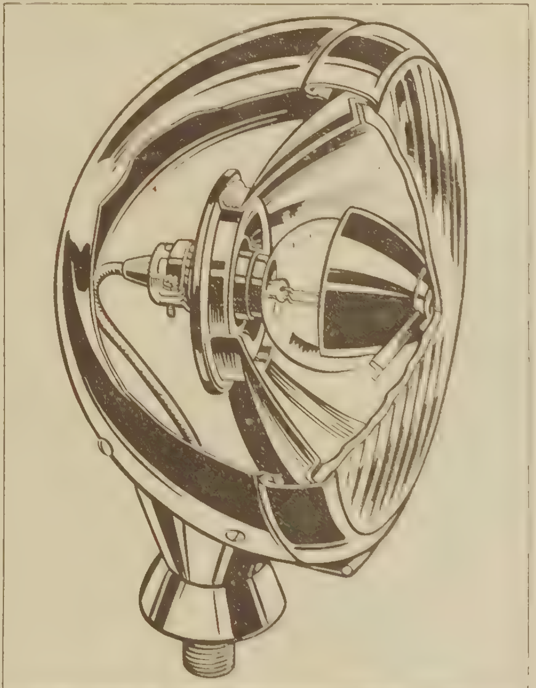


Fig. 343.—Lucas Foglamp, Type FT.

When replacing the reflector mounting in the body, it should be noted that the locating pip, at nine o'clock in the body, should enter the groove in the reflector mounting.

Foglamps

Various types of foglamps now available enable a concentrated high-intensity beam of light to be used for driving under fog conditions; in some instances the non-dazzle types are often used instead of headlamps for ordinary night driving.

When fitting a foglamp, the supporting bracket must be exceptionally rigid and securely held to the chassis by at least two bolts and nuts, with lockwashers. The present legal requirements forbid the fitting of a foglamp with its beam lower than 2 ft. above the ground for normal use.

If fitted below this height the lamp can only be used for driving in fog or snow. There is no upper limit to the permissible lamp wattage, although for practical reasons this is generally limited to 48.

Removing Headlamp Fronts and Reflectors

The following notes refer to the non-pre-focused bulb type Lucas headlamps.

Removing Lamp Front.—Slacken the single securing screw and move it donwards from the slot in which it fits. When replacing the front, locate the top of the rim first, then press on at the bottom, and tighten the fixing screw (Fig. 344).

Fig. 344.—Removing the Front from Bottom of Lamp First.

Removing Reflector.—The method of removing the reflector varies with the different types of lamp; the most common methods are described and illustrated here.

(Fig. 345) Turn back ends of cork washer as shown and remove screw opposite medallion in top of lamp. Turn reflector until markings " O " stamped on reflector rim and lamp body coincide; the reflector can then be withdrawn.

When replacing reflector, engage it with the lamp body, then turn it until the screw-hole in its rim is opposite to the left-hand screw-hole on top of lamp body. Secure reflector by means of screw.

(Fig. 346) Dislocate bottom two supports by pressing inwards as shown, finally dislocating the reflector from the top support.

When replacing the reflector, locate slot marked " L " on the rim with top support, then fit reflector on the other two supports.

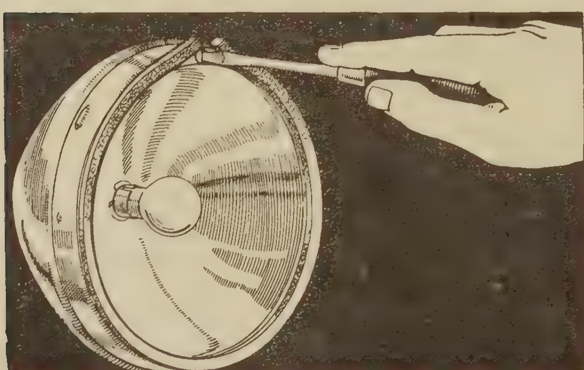


Fig. 345.—Reflector Located by Screw in Rim.

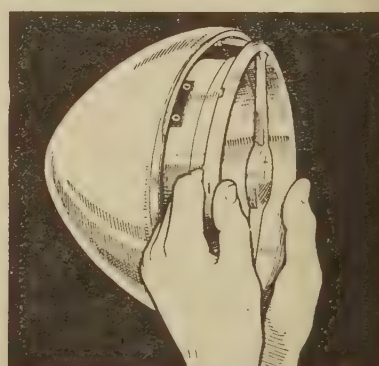


Fig. 346.—Reflector Secured on Three Supports.

(Fig. 347) To remove the dipping reflector, withdraw the fixing screw at the back of the lamp shell. This enables you to withdraw the reflector by dislocating the tongues of the two fixing brackets fixed to the reflector rim from the slots in the lamp body.

(Fig. 348) With this type of lamp, the reflector is combined with the lamp front. To remove the bulb holder from the back of the reflector, move aside the two spring clips securing it and withdraw it from the back of the reflector.

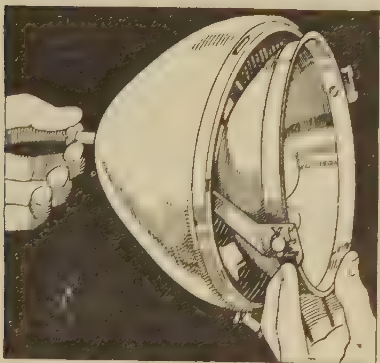


Fig. 347.—Reflector Secured by Screw at Back.

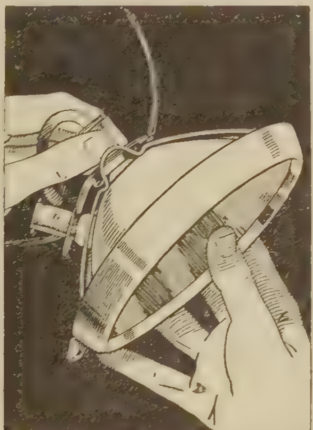


Fig. 348.—Removing Bulb Holders from Combined Front and Reflector.

Lucas Sidelamps

The majority of sidelamps are arranged so that they can be aligned in a manner similar to that described for the headlamps. In addition, with some sidelamps, provision is made for focusing. The focusing arrangement consists of alternative positions for the bulb in its holder; try each position for the best results.

To Replace Sidelamp Bulbs.—The method of replacing the bulb varies with different types of lamps. The various methods are described below.

(1) Twist the front in the direction of the arrow for a complete turn, when the front, together with the reflector, can be withdrawn. The bulb holder is clipped on the back of the reflector, and should be withdrawn by pulling it out. If it is a tight fit it can be carefully levered off with a small screw-driver. When replacing, fit the front so that the arrow is in the ten o'clock position, and the front engages with the lip on the top of the body. Press on and turn the front until the arrow is at the top of the lamp.

(2) Turn the coin-slotted screw at the top of the lamp. This will remove the lamp front and reflector. The bulb holder can then be pulled

away from the back of the reflector. When replacing the front, turn the slot of the screw until it is parallel with front, replace the front on the body so that the screw is opposite to the medallion and then press on (Fig. 350).

(3) Withdraw the two securing screws and lift the lamp body and glass

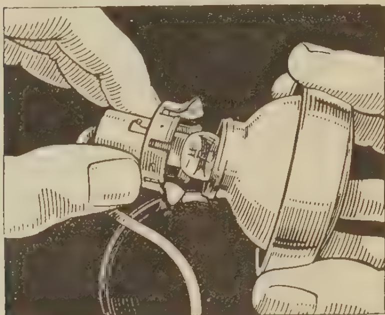


Fig. 349.—Replacing Bulb on one Type of Headlamp.

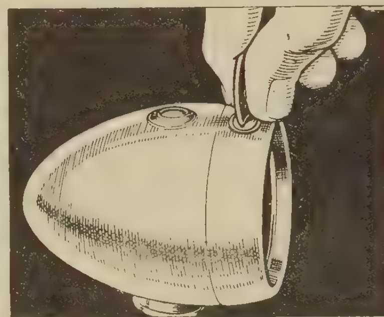


Fig. 350.—Using a Coin to Remove another Type of Sidelamp Cover.

from the base. When replacing, ensure that the rubber washer is in position so that glass will fit on it (Fig. 351).

(4) Slacken the screw at the bottom of the lamp and withdraw the front and reflector. Pull the bulb holder from the back of the reflector (Fig. 352).

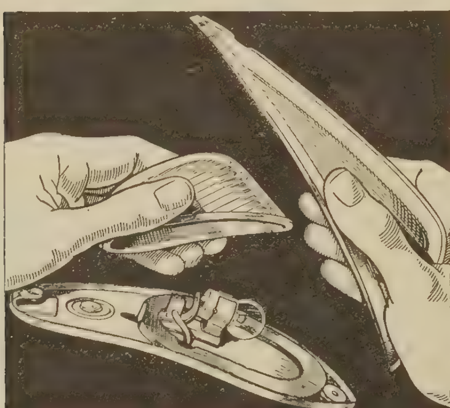


Fig. 351.—Streamlined Sidelamp, showing method of reaching Lamp Bulb.

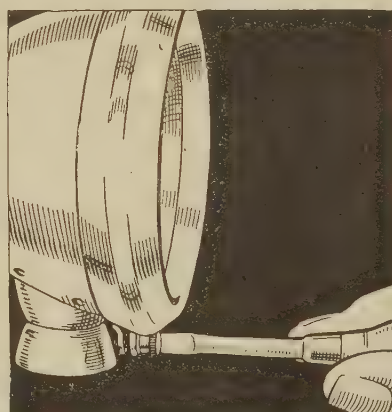


Fig. 352.—Cover held by Clamping Screw at Bottom.

When replacing the front, locate the top of the rim first, then press on at the bottom and tighten the fixing screw (Fig. 352).

(5) Press in the lamp front and turn it to the left as far as it will go to detach it from its bayonet fixing. The bulb is then accessible. When

replacing the front, press it on to the body and turn it until the mark on the rim is at the top of the lamp (Fig. 353).

(6) Withdraw the securing screw on the lamp stem and then pull the

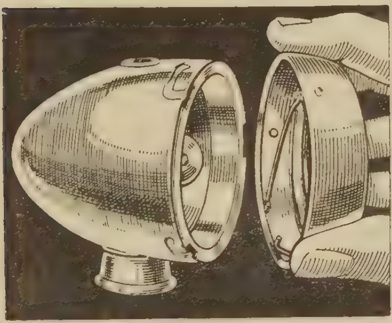


Fig. 353.—Bayonet Catch and Spring Cover.

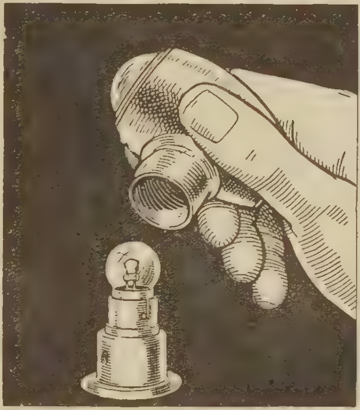


Fig. 354.—Lamp Body held by Screw on Lamp Stem.

body away from the base. The bulb can then be removed from its holder.

Replace the lamp body and secure with the screw (Fig. 354).

Flush-fitting Sidelamps

In many of the more recent cars the sidelamps are fitted flush with the surface of the wings. The method of bulb removal for this pattern of sidelamp is as follows: First slacken the two rim-fixing screws when the front rim and glass can be removed. Next remove the small securing screw from the top of the lamp, which can then be pulled from the body by moving the top of the lamp forwards and downwards. Access to the bulb is obtained by twisting the lamp front in either direction to remove it from the body (Fig. 355). When replacing the lamp, locate the metal tag at the bottom of the lamp first. In the case of the flush-fitting model shown in Fig. 356,

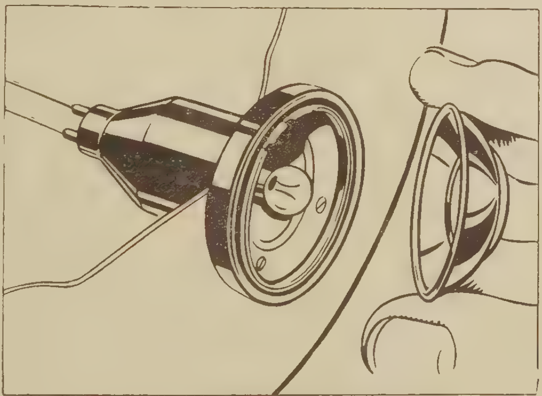


Fig. 355.—Removing Cover Glass of Lucas Flush-fitting Sidelamp.

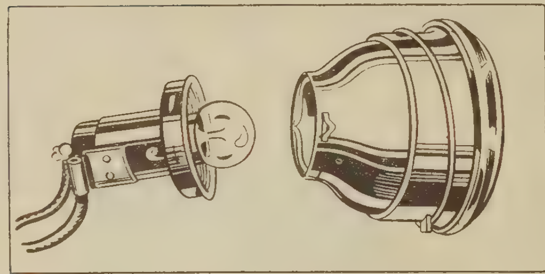


Fig. 356.—The Lucas Flush-fitting Sidelamp.

move aside the rubber ring and prise off the rim with its glass from the bottom of the lamp. To refit, move aside the rubber ring, locate the rim at the top of the lamp and press the rim on; finally position the rubber so that it fits evenly around the rim.

Fitting and Focusing Lucas Foglamps

The more recent foglamps are designed to give a flat-top beam. Legal requirements for foglamps are that these must be set at a height of not less than 2 ft. above the horizontal plane on which the car is standing. The foglamp must be adjusted so that the beam does not rise above the horizontal when the car is on level ground. To ensure this, lamp should be dipped slightly to compensate for road inequalities or extra weight in the rear of the car. Also the lamp should be tilted to allow for road camber. It is a further advantage to tilt the lamp slightly to the left of the axis of the car to ensure maximum illumination of the near-side of the road. The lamp should be focused to give the brightest semi-circular beam of light with the flat-top portion below eye-level. To make this adjustment with the Lucas foglamp (Model FT), remove the lamp front and reflector, slacken the clamping clip at the back of the reflector, and slide the bulb holder backwards or forwards, noting the effect after each adjustment with the reflector and front fitted, until the best beam has been obtained. The front and reflector can be removed after pulling out the spring clip at the bottom of the lamp. When replacing, locate the top of the rim first and then press the front on.

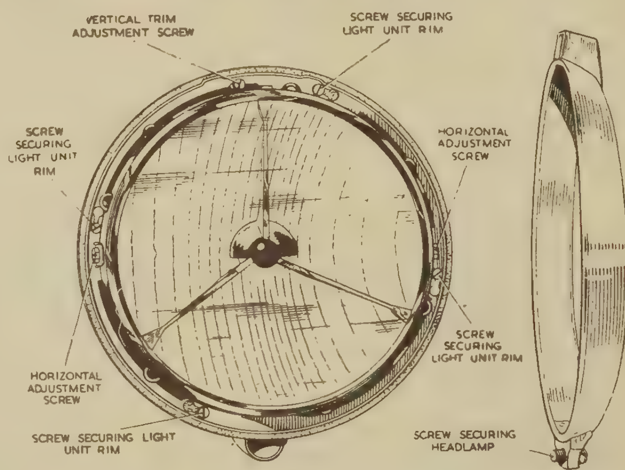


Fig. 357.—The Lucas Foglamp, showing Method of Adjustment.

Rear, Panel, and Dash Lamps

In connection with the smaller Lucas lamps, the following are the maintenance points:

Rear Lamps.—With some tail-lamps the front can be removed by unscrewing it to the left. With others, remove the front portion of the lamp by turning it to the left and withdraw it from base. When replacing, see that the studs locate with the slots in the lamp front, then push it home to lock it in position.

The fronts of some stop, tail, and reversing lamps are secured by means of a single screw. Withdraw this and the front comes off quite easily. With other types, the lamp front can be swung open when the fixing clip is pressed back. The fronts of combined rear lamps and number-plate boxes can be withdrawn when the four knurled and adjust fixing screws are removed.

Panel Lamps and Dash Lamps.—Panel lamps in instrument panels are usually accessible from back of panel.

With some types, bulb holders can be released from the back of panel for bulb replacements by pulling them out or turning them to the left (as viewed from back of panel). With other types, bulb holders are mounted on hinged brackets which move upwards, leaving bulb accessible.

With dash lamps the cover can easily be withdrawn from the lamp body for a bulb replacement.

Ignition Warning Lamp.—To remove warning lamp bulb in the majority of panels, unscrew front carrying red glass. With non-detachable fronts, release bulb holder from back of panel by pulling out or by turning to the left.

Replacement of Bulbs.—When the replacement of a bulb is necessary it is important not only that the same size bulb is fitted, but that it has a high efficiency and will focus in the reflector. Cheap and inferior replacement bulbs often have the filament of such a shape that it is impossible to focus correctly; for example, the filament may be to the one side of the axis of the bulb, resulting in loss of range and light efficiency.

It always pays one to fit bulbs recommended by the lamp manufacturers, as then these problems will not arise.

Cleaning Lamps.—Lucas reflectors are protected by a fine transparent, colourless covering; accidental finger marks can be removed with chamois leather or soft cloth without affecting reflector surface. Never use metal polishes. Only a light polish with a soft cloth is necessary.

Clean ebony-black lamps with a good car polish. Chromium-plated lamps will not tarnish and only need wiping with a damp cloth occasionally.

Windscreen Wiper

The now universal electric windscreen wiper employs a small electric motor with a reduction-gear-driven mechanism for reciprocating the wiper blade arm in a sector path.

To start the Lucas pattern of wiper shown in Fig. 358, pull out the handle to disengage it from the switch. Then move switch lever to " on " position. To stop, move the switch to " off " position, pull out the handle to disengage the wiper blade from the gears and turn the end of the handle into the top of the switch control.

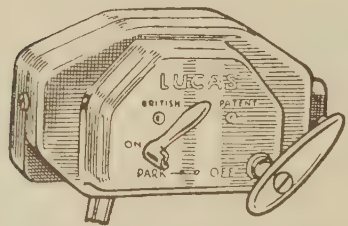


Fig. 358.—Lucas Windscreen Wiper (Model CW).

Replacement of Arm and Blade Assembly.—To remove the arm and blade assembly, slacken the fixing nut and tap it sharply to release the collet which clamps the arm on to the spindle. Then remove the complete assembly. When fitting the replacement arm and blade, slacken the securing nut and push the arm fixing bush over the end of the spindle as far as it will go. Secure by tightening the nut.

Replacement of Blade.—Take out the rubber bush securing the blade to the arm and remove the blade. Insert the tongue on the replacement blade through the slot in the arm, and secure it by fitting the rubber bush through the hole in the tongue. The bush can be fitted more easily if it is moistened.

The Lucas wiper motor as supplied new is adjusted and packed with grease so that it requires no further attention. A drop of thin oil should be applied occasionally where lubricators are provided.

The later Lucas wiper arm is fixed to the operating spindle by two different or alternative methods, as shown at A and B in Fig. 359. In the case of A the arm and blade assembly can be removed by first slackening the fixing nut shown and then tapping the end sharply to release the collet which clamps the arm on the spindle. When re-fitting, slacken the securing nut and push the arm fixing bush over the spindle as far as it will go; then tighten the securing nut.

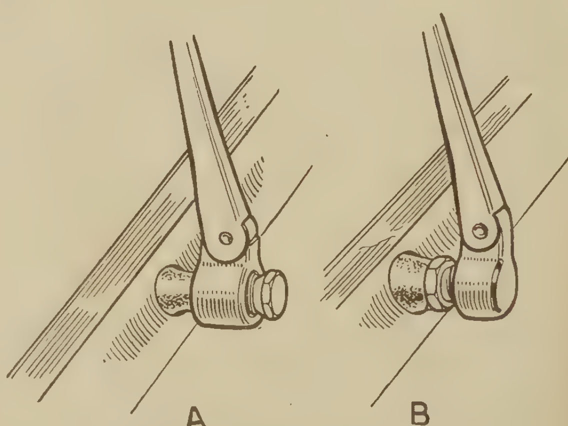


Fig. 359.—Illustrating Two Methods of Fixing the Lucas Wiper Arm and Blade to the Wiper Spindle.

In the case of arm and blade assemblies shown at B the screw securing the arm and blade assembly is designed so that it also takes the form of an extractor. To remove the arm and blade assembly slacken and rotate the fixing screw until the assembly is freed from the spindle.

To fit a new blade to the later model, lift the arm and blade from the

windscreen and press the blade and arm together. In the same movement slide the blade off the curved part of the arm. *To replace*, insert

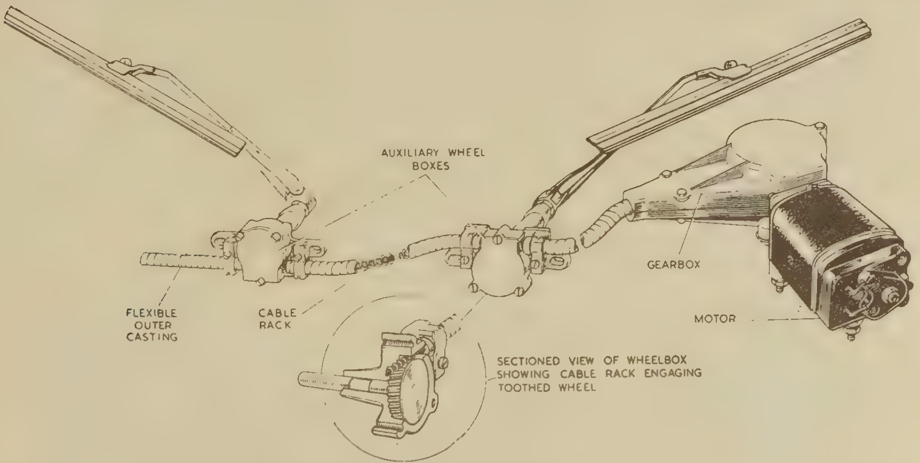


Fig. 360.—The Lucas Double-arm Windscreen Wiper.

the curved portion of the arm in the slot of the blade swivel and slide the blade into position. Occasionally smear lightly with grease both sides of the curved portion of the wiper arm which fits into the slots of the blade swivel.

The C.A.V. Windscreen Wiper.—A good example of a commercial-vehicle windscreen wiper is that of the C.A.V. type shown in Fig. 362. It consists of a small electric geared motor which drives the arm holding the squeegee or wiper blade. The oscillatory movement of the arm is produced by means of a crank connected to the reduction gears. A control switch is incorporated in the end cover.

Referring to Fig. 362, the worm A is cut on the end of the armature shaft and drives the worm wheel B with a high-

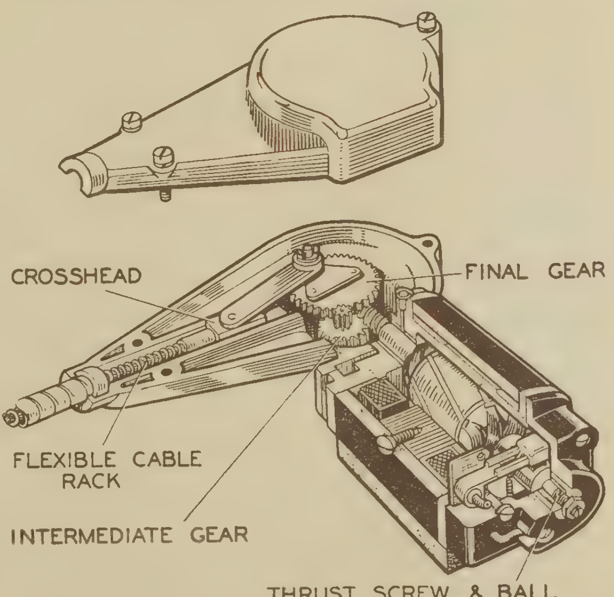


Fig. 361.—The Electric Motor and Operating Gear of Lucas Windscreen Wiper.

reduction ratio. The latter carries the crankpin C, which by means of the connecting rod D gives the toothed segment E an oscillating motion. The toothed segment E engages on one side with the pinion F fixed to the wiper spindle so that the latter oscillates with the toothed segment.

In connection with the position of the wiper blade on the spindle there is a punch mark N (Fig. 362) to indicate the correct position.

Maintenance.—If the wiper does not operate satisfactorily and it is

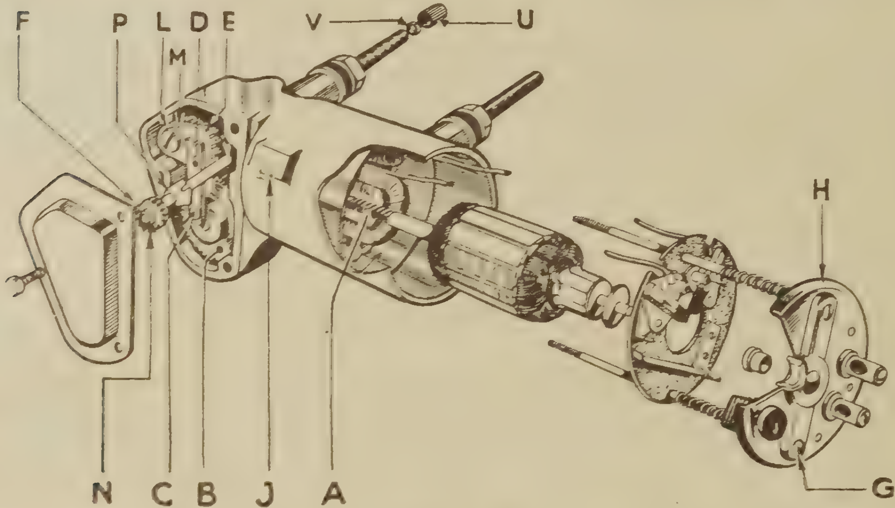


Fig. 362.—The C.A.V. Windscreen Wiper, Type BWN (Leyland).

A, Worm. B, Worm Wheel. C, Crankpin. D, Connecting Rod. E, Toothed Segment. F, Pinion on Wiper Spindle P. G, Screws. H, End Cap. J, Driving End Bearing. L, Screw securing Worm-wheel Assembly. M, Lock Washer. N, Punch Mark for Location. U, Gland Nut. V, Washer.

known that the gearing is quite free, the brushes and commutator should be inspected. If the commutator surface is dirty or discoloured it should be cleaned with very fine glass or carborundum paper (do not use emery cloth). After cleaning the commutator surface the slots between the segments should be cleared of all deposit.

The brushes should not be worn below a length of $\frac{5}{32}$ in. (3·9 mm.) and should be properly bedded, i.e. they should be worn to the commutator periphery. If they are not, wrap a strip of very fine glass or carborundum paper firmly around the commutator, and with the brushes in position rotate the armature by hand in the normal working direction of rotation until the correct brush shape is obtained.

It is important that the gland nut U and the washer V (Fig. 362) are retained in position, as they serve the double purpose of preventing dampness from penetrating the wiper and also eliminate any leakage of grease.

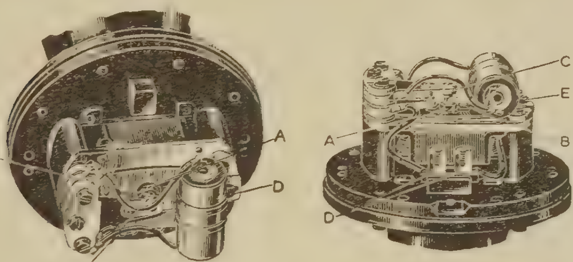
The Electric Horn

This seldom requires any attention, except a few drops of light machine oil in the bearings every few thousand miles.

In the majority of electric horns of the solenoid or motor types, some form of diaphragm adjustment is provided. A careful examination will reveal a small adjusting screw—usually with its lock-nut—for this purpose.

The Lucas Alto Horn.—The high-frequency-note type horn is shown in Fig. 363 with its covers removed.

The horn should be properly mounted on the car, great care being necessary to ensure that it is securely clamped to a substantial member

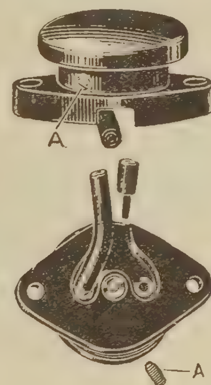


(A) (B)

Fig. 363.—The Lucas Alto Horns with Cover removed.

Type (A) A, Locking Nut.
B, Striking Screw.
C, Insulator on End of Spring Blade.
D, Condenser.

Type (B) A, Locking Nut.
B, Striking Screw.
C, Insulator on End of Spring Blade.
D, Terminals.
E, Condenser Securing Screw.



(C)

(C) The Horn Switch
A, Grub Screw.

of the chassis frame. A special spring bracket is supplied with the horn for this purpose; it should always be used. The wiring should be carried out with single 5-mm. ignition cable.

The horn-switch cover is secured by two screws. When the cover is removed the cable ends can be secured in the two terminals shown in Fig. 363 (C) by means of the grub screws A.

One terminal of the horn must be connected to the battery supply terminal; the other should be connected to one terminal of the horn push-button unit and the other terminal of the latter to the chassis frame or "earth" in single-pole wiring systems. In most Lucas switchboxes and instrument panels the supply terminal is marked "A," and the earth return or negative terminal "— B".

Adjustment.—These horns will give long periods of service without any attention, but a means of adjustment is provided if required. For instance, should the horn become uncertain in its action, giving only a choking sound, or does not vibrate, it does not follow that the horn has broken down. First ascertain that the trouble is not due to some outside source, e.g. a

discharged battery, a loose connection or short circuit in the wiring of the horn, or in some cases a blown fuse.

To adjust the horn (Type A), proceed as follows: slacken the locking nut A, and turn the striking screw B a fraction of a turn towards the insulator C on the spring blade. To facilitate making the adjustment, the condenser D, which is secured by a clip and screw, can be easily removed. The best position for the adjustment screw can readily be found by trial. Care must be taken that the locking nut is tightened up every time the horn is tested.

It is important that no other screws are touched, otherwise the performance of the horn may be impaired.

Wind Tone Horns.—After long periods of service it may happen that these will need adjustment.

Adjustment does not alter the pitch of the note but merely takes up wear of moving parts. When adjusting the horns, short circuit the fuse, otherwise it is liable to blow. Again, if the horns to not sound on adjustment release the push instantly.

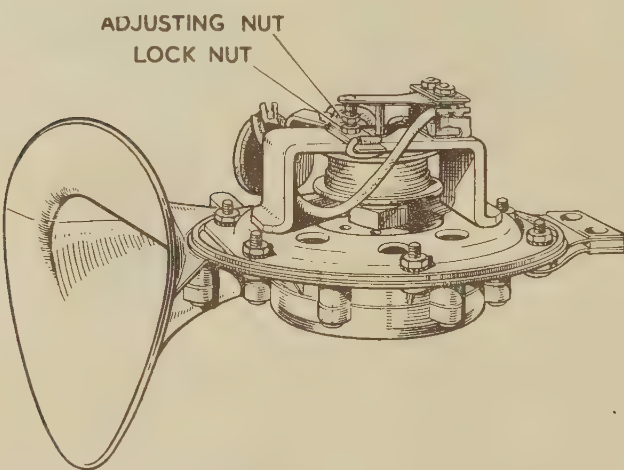


Fig. 364.—Adjusting Lucas Wind Tone Horn.

When making adjustments to a horn, always disconnect the supply lead of the other horn, taking care to ensure that it does not come into contact with any part of the chassis and so cause a short circuit.

Remove the horn cover after withdrawing the fixing screw and detach the cover-securing bracket by springing it from its fixing.

Slacken the lock-nut (Fig. 364) on the fixed contact and rotate the adjusting nut until the contacts are just separated (indicated by the horn failing to sound). Turn the adjusting nut half a turn in the opposite direction and secure in this position by tightening the lock-nut. If the note is still unsatisfactory, do not dismantle the horn but return it to a Lucas Service Depot.

Notes on Electric Horns.—If a horn fails or becomes uncertain in its action, do not conclude that the horn has broken down. First ascertain that the trouble is not due to a discharged battery or a loose connection or short circuit in the wiring of the horn. A short circuit in the horn wiring will cause the fuse, if one is fitted, to blow. When two horns are fitted, if both fail or become uncertain in action, the trouble is probably due to a

blown fuse or a discharged battery. If the fuse has blown, examine the wiring for fault, and replace the fuse with the spare provided.

C.A.V. Commercial-vehicle Horns.—The adjustment of these horns is illustrated in the case of Bedford vehicles in Fig. 365. Adjustment should only be necessary if the horn is used repeatedly when badly out of adjustment.

Adjustment is effected by turning the adjusting screw, shown at the back of the case in Fig. 365. When doing this, allowance must be made for the increase in the available voltage which occurs when the engine is running. Whilst stationary, the voltage will be a little over 12, but with the engine running, and charging, it may be as high as 16.

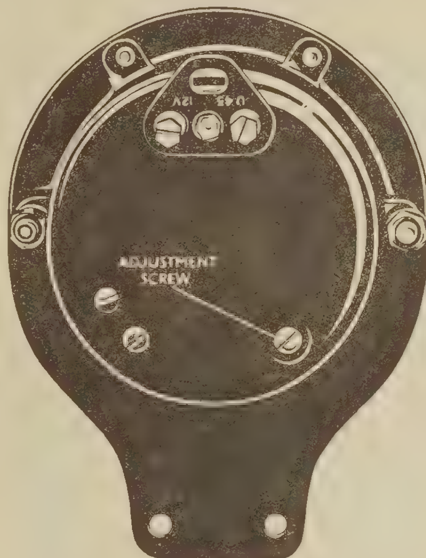


Fig. 365.—Adjustment of C.A.V. Electric Horn.

To allow for this variation, adjust the horn to give the best note with the adjustment screw turned to the left until the note is on the point of falling off. This will also have the effect of making allowance for normal wear, and thus prolonging the time before adjustment is again necessary.

When making the adjustment, do not continue to use the push if the horn does not sound.

If, when the push is operated, the horn does not take any current (though current is reaching the horn leads), it is possible that the contact breaker, through maladjustment, is permanently open.

Diagnosing Horn Troubles

Horn Note Unsatisfactory

Cause	*Remedy*
Horn loose on its mountings	Tighten mountings.
Loose connection in wiring	Trace and rectify.
Horn out of adjustment	Adjust.
Foreign matter preventing free movement of tone disc	Clean and readjust.

Horn will not Operate

Cause	*Remedy*
Faulty connection	Clean and tighten.
Fuse blown	Check for short circuit and replace fuse.
Internal fault	Recondition or renew.

Maintenance of Trafficators

The Trafficators made by Messrs. Lucas, Ltd., are fitted with 12-volt Lucas No. 256 or 6-volt Lucas No. 255 bulbs, each of the 3-watt festoon type.

The following are the items of maintenance:

Lubrication.—Every two to three months, or if the arms become stiff at any time, raise each arm and, by means of a brush, matchstick, or other suitable article, as illustrated, apply a drop of thin machine oil, such as sewing machine or typewriter oil. Only the merest drop of oil should be used—any excess may affect the working of the operating mechanism. The Trafficators are kept in the closed position by means of a spring.

The arms can be pulled out by hand. If any difficulty is experienced, switch the Trafficator on, and then, supporting the arm in a horizontal position, move the switch to the "off" position. The methods of lubricating two different models of the Trafficator are illustrated in Figs. 366 and 367.

Fig. 366.—With this model, apply a drop of thin machine oil to the catch pin between the arm and the operating mechanism.

Fig. 367.—With this model Trafficator, apply a drop of thin machine oil to the two hinged joints between the arm and operating mechanism.

Replacing a Bulb.—If at any time the arm fails to light up when in operation, raise the arm in the manner previously described, and examine the bulb, replacing it, if necessary, with one of the same size and wattage as fitted originally.

Do not attempt to remove the bulb holder while the Trafficator is switched on, as this may cause a short circuit.

The methods of replacing bulbs in the external and flush types of Trafficator are illustrated in Figs. 368 and 369. In the case of the model shown in Fig. 369, to replace the bulb withdraw the screw on the underside of the arm and slide off the metal plate; the burnt-out bulb can then be replaced. To replace the metal plate, slide it on in an upwards direction, so that the side plates engage with the slots on the underside of the spindle bearing. Finally, secure the plate by means of its fixing screw.

Dismantling and refitting Trafficator Arm.—A faulty trafficator can be removed by disengaging the casing from the car body pillars. Usually the casing is secured by six screws, with each screw having a cup washer under its head. It is necessary first to turn back the felt lining under

the casing in order to reveal the actual trafficator screws. Two of these set-screws have a plain and spring washer, and when they are removed the trafficator unit may be pulled inwards away from the door pillar. Finally,

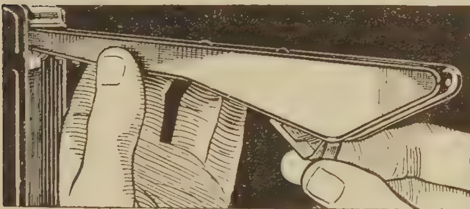


Fig. 368.—Externally-mounted-type Trafficator. Withdraw the bulb holder which is clipped into the underside of the arm by means of the metal tongue provided.

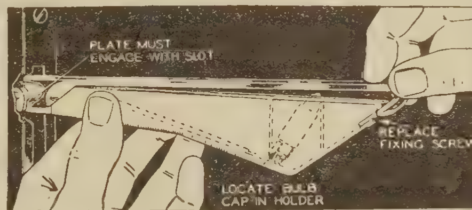


Fig. 369.—Flush-fitting type of Trafficator. Remove the bulb from its holder when the cover is released by moving the small trigger on the underside of the arm.

the single wire snap-joint connection must be released; this joint is inside the body of the indicator.

Next, carefully drill out the rivet shown in Fig. 370, and then remove the arm cover and withdraw the cable and bulb. Finally, open out the clip securing the cable and remove the arm.

When fitting a new arm, place this in position so that the arm stop-pin locates between the arm-lifting plate and locking plate and then secure in place with a new rivet. Remove the arm cover to replace the cable and bulb and refit the cover. Then secure the cable to the arm by means of the clip, taking care to ensure that the bending cover of the clip does not damage the cable or its insulation. Further, see that the cable can move freely when the trafficator is operated.

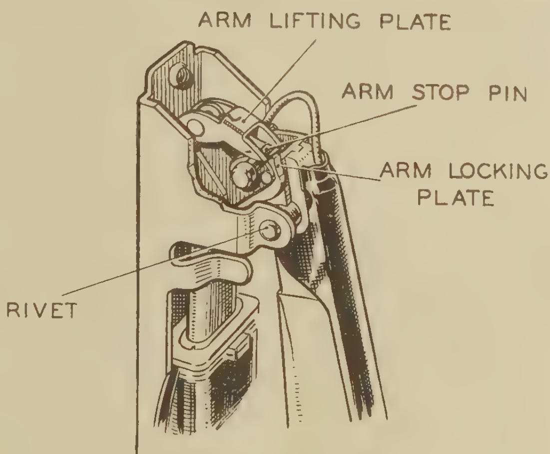


Fig. 370.—Dismantling Trafficator Arm (Lucas).

Electric Petrol Gauges

The electric petrol gauge, which has to a large extent superseded the pneumatic type with coloured fluid indicator, consists of two units, namely, the indicator or dial unit, which is mounted on the instrument panel, and the petrol-tank-operating unit.

The indicator consists of two coils wound so that they have the same

polarity in the faces exposed to the armature, which is integral with the pointer. The dial of the indicator is graduated between "Empty" and "Full" (Fig. 371) and marked "E" and "F," with a half-full position also.

The tank unit consists of a housing enclosing a resistance unit with a moving arm which is actuated by a float arm immersed in the petrol tank.

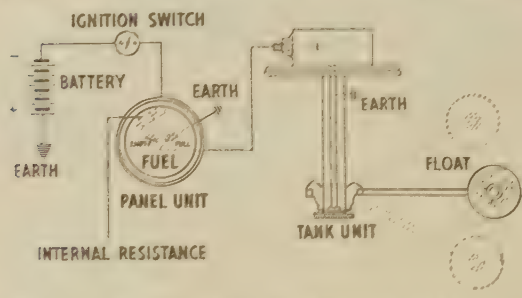


Fig. 371.—Showing Principle of Electric Petrol Gauge (Vauxhall).

The outer terminal of the instrument-panel unit is connected to the ignition switch so that the gauge operates only when the ignition is switched on. The centre terminal is connected to the terminal of the tank unit. The electrical circuit is completed through the chassis for both panel and tank units.

Operation.—When the petrol tank is empty the tank floats are at their lowest position and the resistance in the tank unit is completely cut out; this results in one of the coils in the dash unit being rendered ineffective, and the other coil attracts the armature, causing the indicator to point to "Empty."

As the petrol tank is filled the float rises and the resistance is continually increased in the circuit of one coil, causing it to become weaker, and the resistance is gradually lessened by the same amount in the other coil, which accordingly becomes more powerful and attracts the indicator towards "Full" on the gauge. The same action is reversed as petrol is consumed and the indicator moves towards "Empty" in proportion to the quantity of petrol used.

The design of the petrol gauge is such that the current consumption is very low, approximately one-eighth ampere.

As the operation of the petrol gauge does not depend on the strength of the magnetic field, fluctuations in the battery voltage will not affect the gauge reading.

Removal of Petrol Gauge Units. (1) *The Panel Unit.*—This is removed by first disconnecting both cables from the battery, removing the two securing nuts behind the instrument panel and then easing the panel forward as far as the electrical harness will allow. Then the cables can be disconnected from the fuel gauge after noting the cable colours so as to replace them correctly. Finally, remove the screws attaching the fuel gauge to the cluster panel and withdraw it.

(2) *The Tank Unit.*—First remove the round seal disc in the (Vauxhall "Velox") luggage compartment floor. Then disconnect the cable from the terminal on the tank unit and remove the screws attaching the tank unit to the fuel tank; it can then be withdrawn from the tank. The unit is dismantled by first removing the three countersunk screws attaching the

float bracket to the head of the unit so that the head can be taken off.

Inspection of Petrol Gauge Units.—(1) *The Panel Unit.*—This should be examined for free movement of the pointer over its full range. Next, check the two coil-retaining nuts for brightness. Finally, inspect and, if necessary, clean the earthing plate between the two terminals and check the soldered connections.

(2) *The Tank Unit.*—Check the float arm for free movement; the arm should fall under its own weight. Then examine the contact shoe for over-

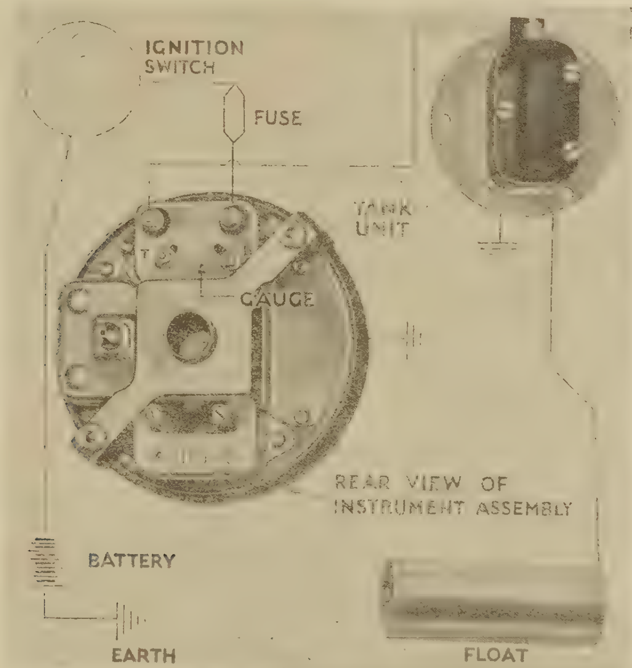


Fig. 372.—Electric Petrol Gauge used on Standard Cars. (This operates on the principle described in the text.)

heating and see that there is sufficient tension to bear on the resistance. Finally inspect the resistance strip for overheating and fracture and ensure that there is complete contact throughout the length of the resistance.

Testing the Petrol Gauge.—The complete assembly should be tested on the bench by first connecting a cable between the tank terminal and panel unit (tank) terminal. Connect up the 12-volt battery as on the car, i.e. with the positive to earthing plate of the panel unit and negative to battery terminal of the panel unit. Close the battery switch and move the float arm up and down. The panel pointer should follow the position of the float arm if the assembly is in satisfactory condition.

CHAPTER 10

ELECTRICAL REPAIRS AND ARMATURE REWINDING

THE electrical equipment of the modern car is, as a rule, remarkably free from troubles, considering its severe conditions of use. It speaks well for the design of such complex structures that they are able to withstand the vibration, dust, damp, and other adverse conditions which are inseparable from road service; but now and again trouble crops up and necessitates the renewal of existing parts, or the repair of old ones. This chapter will be devoted to the more detailed tracing of faults, and to such repairs that can be efficiently carried out in the garage or workshop, without reference to the factory. The information given applies to most automobile dynamos and motors.

Repairs versus Replacements

Before proceeding further, a word of warning may not be out of place as regards electrical repairs in general, and that is to consider well before starting to dismantle, test, or repair the damaged or defective item whether it is not cheaper to replace the part with an entirely new one rather than to spend the time in a more or less temporary repair.

Standardisation of dimensions and mass production have reduced factory costs to such a point that it is often less costly to purchase an entirely new replacement part than to repair the damage, if it is of such a nature to entail special tools and jigs in its manufacture. It is easy to put considerable time into a repair with somewhat doubtful results in the end when one is unfamiliar with the work, and if the circumstances are such that the job is viewed on the cost basis alone it may prove unprofitable in the end, even though a satisfactory repair is achieved. Apart from this aspect, however, the knowledge and experience gained in carrying out the repair are often of great service at unexpected moments, and there is much satisfaction in getting better acquainted with the inner details.

Car Dynamos and their Ailments

Beginning with the car dynamo and the various ailments it is liable to develop, one of the soundest rules to observe is not to wait until it actually

breaks down, but to overhaul it, say, once in every six months, cleaning and making any minor adjustments found necessary. An actual breakdown can be postponed almost indefinitely if this rule is attended to, and although natural wear and tear will take its toll in course of time, the feeling of confidence inspired by a knowledge of its internal condition is well worth having.

Owing to its relatively exposed position the dynamo is liable to collect rather more than its fair share of dust and grease, and when any serious trouble develops the very first step is to give it a good clean down externally, using brush and petrol if necessary, but not flooding the inside of the machine. When removing it from the car all connections should be labelled or otherwise marked, so that mistakes are impossible when reassembling. After removing the casing over the brush gear to ascertain that the trouble is something more than merely worn-out brushes or broken or weak brush springs, or perhaps a bad condition of the commutator surface, it is generally advisable to draw the armature and test everything out systematically. This also gives an opportunity of clearing out any dirt or grease that may have collected internally.

Dismantling

And now comes the first difficulty: that of removing the end bearing. Ball bearings are almost universally adopted, and as the inner race is generally located definitely on the shaft by a nut, and the outer race a press fit in the bearing housing, it is sometimes no easy matter to separate them. First remove all brushes from the commutator, and then take out the screws holding the pulley end shield. In some designs there are spigoted bearing-caps holding the ball-races in position, and if the screws which pass through these from one side of the housing to the other are removed the bearing will easily draw out with very little trouble, leaving the ball-races still attached to the shaft. If not they must be pressed out under an arbor press, applying pressure to the outer race by a short length of tube squared at the ends to avoid any sideways thrust. Do not remove the ball bearing from the armature shaft if it can be avoided, as every time this is done it will go back slightly slack.

A very handy device for extracting refractory bearings, gears, commutators, etc., is the "Puller Press," illustrated in Fig. 373, made by the Autocar Electrical Equipment Co., Ltd., London. The bottom plate is machined to take various-sized standard bearings and collets, and its use avoids such things as damaged threads and bent shafts.

After removal of the bearings clean everything out thoroughly inside the dynamo casing, using a minimum of petrol, as it is not good for the insulation. Swill the bearing races through with paraffin, until it comes through quite clean and the races turn without any gritty feeling, and then immediately pack them with bearing grease, which prevents the access of dust while lying about exposed.

Mechanical Faults

Go over the whole machine next and carefully examine for obvious mechanical faults. All troubles are not electrical ones, as is often assumed rather hastily. Bearings may get worn and slack, sometimes even to the point of allowing the armature core to rub against the pole faces; the armature shaft may be bent; the pulley may be loose, so may the pole-pieces in the field ring; all such defects must be rectified as a preliminary.

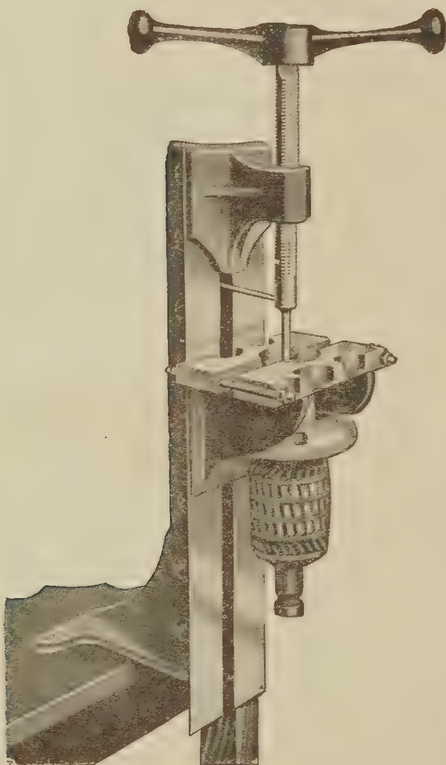


Fig. 373.—The "Puller Press." (Autocar Electrical Equipment Co., Ltd.)

Commutators

It is usually the commutator that shows signs of wear first. One with a blackened irregular brush face will never give a satisfactory performance, and as it is a rather delicate structure especial care is necessary in reconditioning it. The two chief essentials are that it should be perfectly cylindrical and truly concentric with its centre of rotation. In truing up a worn commutator the general practice is to mount the shaft between lathe centres; this may or may not be satisfactory, as although the resulting commutator face may be perfectly true with the centres upon which the shaft revolved it does not follow that these centres are equally true with the ball-races. When the ball bearings are pressed on the shaft it sometimes happens that they shear the metal slightly and take up a new centre as a consequence. The way to guard against this is to chuck the pulley end of the shaft and support the other end in a split collet or lathe-steady engaging with the outer ball-race. The commutator face is then bound to be true when running in its own bearings, irrespective of the shaft centres.

The lightest possible cuts should be taken from the commutator face to remove the effect of wear and tear, using a finely pointed keen tool with an oil-stone finish to the cutting edge, run at a high speed. The surface can be touched up with a dead-smooth file afterwards and finally polished with No. 0 glass-paper. On no account let emery come into contact with the surface, as it becomes embedded more or less permanently in the copper, causing endless trouble afterwards.

The mica separators between the commutator bars should always be recessed to a depth equal to the thickness of the mica, using a special slotting saw of the exact width necessary to completely clear the mica away, after which the face is again polished with glass-paper. Undercutting the mica in this way is a great aid to satisfactory performance, since on low-voltage dynamos and motors where soft high-conductivity brushes are employed the brushes have little or no abrasive action of their own to keep the mica down; in course of time the copper wears down more than the mica, thus preventing that intimate contact between bar and brush so essential to good commutation.

While the armature is out of the machine look over the binding bands on the end windings; also see that any slot wedges which have worked loose are made fast again.

Brush Adjustments

After the remarks concerning the importance of a good commutator surface, it follows naturally that the same importance attaches to the proper condition of the brush faces themselves. For sparkless commutation and the avoidance of burnt edges to the commutator bars it is necessary that the brushes bear on the commutator surface all over their faces, not making line or point contact only. This is secured approximately when new brushes are fitted by cutting a few strips of fairly coarse glass-paper for use in grinding them in. Pass one of these strips round the commutator, cutting side next to the brush, and rock the armature to and fro by hand while pressing on the end of each brush in turn in its holder. As soon as the brush face has assumed an approximate curve remove the glass-paper and blow away all loose carbon dust. The final bedding is a longer process and cannot be hastened. As the face of the carbon wears away in the course of natural running, it will gradually come into still closer contact with the commutator surface, and should eventually acquire a brilliant gloss, while the track of the brush on the commutator face becomes a dark brown. Some machines never do quite acquire this condition, and in many instances this is because the brushes have never been properly bedded down at the start; the consequence is that initial bad contact has caused sparking which, by roughening the commutator surface, rendered it impossible ever to arrive at the desired perfection of contact.

Brush Holders and Springs

Even if bedding down is satisfactory in the first instance, no brush can continue to work satisfactorily unless the brush springs are doing their duty too. Attention, therefore, should always be directed to the condition of the brush guides and springs. Everything here must be clean and free from oil, the spring feeding the brush crisply when the latter is lifted off the commutator face by its flexible attachment. The fit should not

be too slack between the sides of the brush and its box guide or it will chatter; nor must it be so tight that the spring cannot feed the brush with perfect freedom when everything is hot; brushes expand appreciably when hot. The box guides themselves should support the brushes to within $\frac{1}{16}$ in. of the commutator face.

The spring tension is usually adjustable, and should be set so as to give a pressure of $2\frac{1}{2}$ to 3 lb. per sq. in. cross-sectional area of the brush.

Brush Grades

Most brushes used on car dynamos and starters, and on low-voltage machines generally, consist of a special copper-carbon mixture, and the grade of brush originally supplied with the machine when new should always be retained when replacing worn-out or damaged brushes. It is a great mistake to think that any sort of carbon will do; there are dozens of different grades with varying conductivities and totally different characteristics, and the performance of the dynamo or starter may be very adversely affected by substituting a brush of the wrong grade.

Electrical Faults

Having examined the machine thoroughly for mechanical faults, attention can now be directed to faults of an electrical nature. Most of the troubles, speaking broadly, are associated with brushes and commutators. Broken connections between coils and terminals come next. A wire sometimes breaks inside its insulating covering, and an inspection for such faults needs to be a searching one.

If the connections all prove sound the remaining source of trouble lies in either the armature windings or the field coils, and may be in the nature of open circuits or short circuits. An open-circuited armature usually locates its own trouble by blackening certain commutator bars, these being the ones attached to the ends of the coil containing the break. An open-circuited field coil is easily recognised by failing to pass any current when the two coil ends are attached to a battery and ammeter.

Short circuits are not always so easy to detect. In the armature they may be partial or total; in the latter case one or more of the coils themselves appear blackened where the insulation is charred by excessive current circulating internally round the shortened section, also there is a very distinctive smell of burnt insulation.

Short-circuited field coils do not burn out, and have to be detected by other means.

Coil-winding Tester

The " Echo " armature tester described in Chapter 7 will be found very useful for testing armature windings during the progress of the work for short circuits, open circuits, crossed circuits, etc.

Fig. 374 illustrates the method employed for making such tests on an armature in the process of winding and, as explained previously, the presence of a short circuit is indicated by a loud note from the instrument as it explores the windings.

Armature Fault Testing

Any serious fault can usually be found in an armature by applying the " Growler " test. This is an alternating-current test, and the device is seen in Fig. 265 on page 260. The appliance consists of a laminated C-shaped iron electro-magnet, the coil being excited by alternating current from the mains, under control of a switch, and a small pilot lamp shows when it is " live." When an armature core is placed in the V-shaped opening between the pole-tips of the growler an alternating magnetic flux passes through the armature windings, producing in them an electro-motive force in proportion to the number of turns and the strength of magnetic flux, following the same laws as those which operate with the ordinary A.C. transformer. When the armature coils are all sound they present a sufficient opposing inductance to keep the flux down to a small value, and the growler magnet hums faintly. If, however, the armature happens to contain a short-circuited coil, upon rotating the core slowly this coil is brought under the influence of the alternating flux from the magnet, and behaves exactly as though it were a short-circuited secondary winding in a transformer. It takes an excessive current and causes the magnet to hum loudly or " growl."

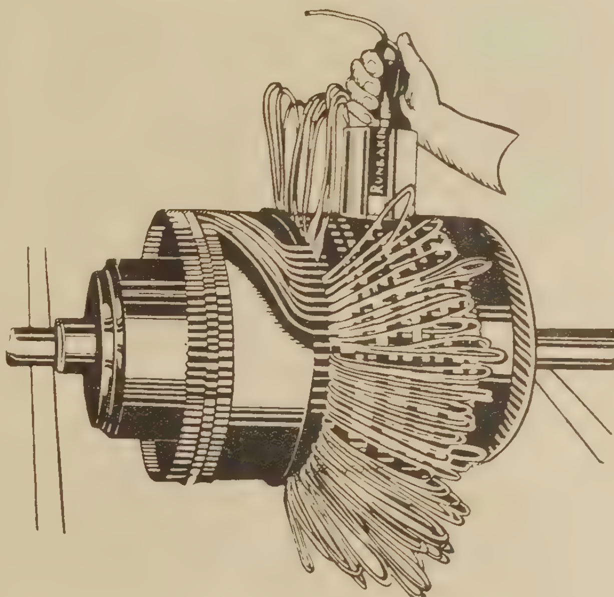


Fig. 374.—The "Echo" Armature Tester

Drop Testing.—Partial short circuits are not always recognisable by these means, and if any serious doubt is felt as to the armature condition recourse is made to the " Drop " test, which is not only more searching but can be applied to field coils also.

This is a direct-current test, and consists in passing a measured current

through the coils, all in series, and observing the potential difference or volt-drop across the ends of each section by means of a low-reading voltmeter. The method is illustrated by diagram in Fig. 375. It is better to lift the two connections from any one of the commutator bars and separate them for the purpose of this test, as it then ensures all the coils being in series with the same amount of current passing through each in turn; the alternative method of applying current to opposite points of the commutator is open to the objection that the testing current divides between two circuits, one of which may be different in resistance to the other, due to some defect, resulting in unequal distribution of the current. By raising the ends of one coil as advised this cannot happen; also it enables the test for open circuits to be definitely applied, since no current can pass at all if there is only one circuit and that has a break in it.

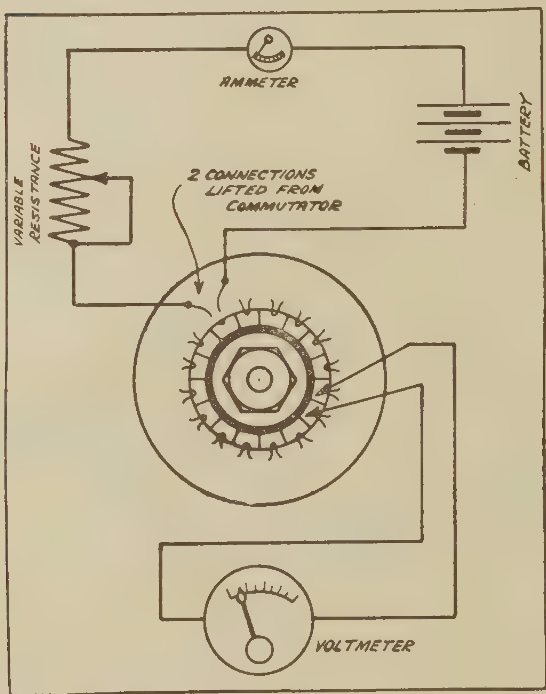


Fig. 375.—Drop Testing for Armature Faults.

The method of taking the test is to pass current from a battery through the armature winding, as shown, with an ammeter and a variable resistance in circuit, adjusting the latter until normal full-load current passes. This current must be kept at a steady value all through the test. Two metal spikes connected with the voltmeter are then applied in turn to each pair of commutator bars, and the voltmeter readings noted down. Should the readings be too high for the voltmeter scale reduce the current; if too low change the voltmeter for one of lower range. For starter armatures a milli-voltmeter is necessary.

The principle involved in this test is that all sound coils on the armature will possess approximately the same resistance, and if therefore the same value of current is flowing through each of them the fall of potential or " volt-drop " as indicated on the voltmeter should be identical. If one pair of commutator bars shows a low reading or none at all it indicates a partial or complete short circuit in that coil whose ends are attached to these bars.

Remember, however, that a fault existing between the commutator bars

will have the same effect upon the drop test as a defective winding would, and if the commutator is suspected all coil connections should be raised from the bars and joined together independently of the commutator; the latter can then be given a "Megger" test for general insulation between bars and from bars to earth.

Testing Devices.—A quicker test than the one just described, but more searching than the growler test, is the ammeter test used in conjunction with a special growler, shown by the device illustrated in Fig. 376. Here the growler magnet is supplemented by a pair of insulated contact fingers used to explore adjacent commutator bars, the flexible connections being in series with an ammeter and limiting resistance. As the armature coils come under the influence of the alternating flux across the jaws of the growler, when rotated slowly, a small E.M.F. (electro-motive force) is induced in them of a magnitude proportional to the number of turns in each section of the windings. If they are all sound these E.M.F.'s will be equal and will pass equal currents through the ammeter. If any turns are defective, however, a lower E.M.F. results, which, applied against the same resistance, shows a correspondingly lower ammeter reading. If the testing spikes are applied to commutator bars more widely separated, crossed or opposing coils can also be detected, since their effects would oppose one another and a null reading result. To discriminate between crossed coils and dead shorts each coil can be tested separately first, then in pairs; if each gives a normal reading by itself, but no reading when in pair with its neighbour, it is clear that one of them is cross connected.

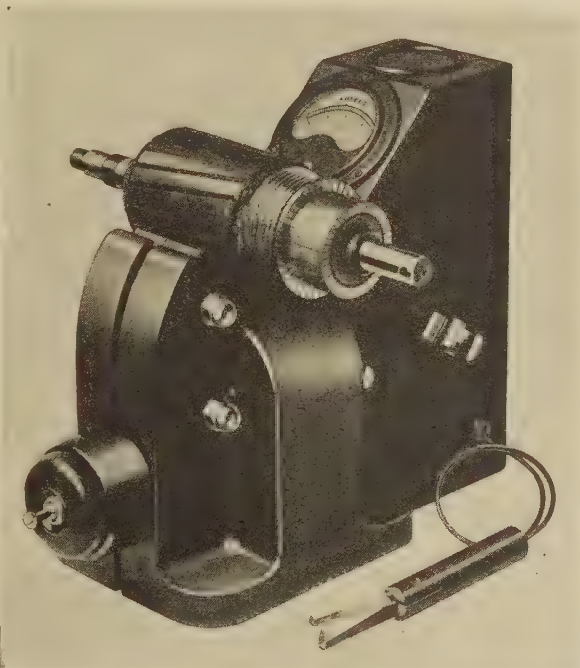


Fig. 376.—Combined Growler and Ammeter for Armature Testing. (Newton's of Taunton.)

There are two points in connection with the use of growler tests which require noting: never leave the growler in circuit without an armature core bridging the gap between the poles, or the excess current taken round its exciting winding in such circumstances may cause a burn out. Another

point is that when testing starter armatures of very low resistance it may be necessary to put the growler coils in parallel to get a sufficiently heavy flux to give a reliable reading.

Field-coil Tests.—The drop test illustrated in Fig. 375 can, as already stated, be used for testing field coils to ascertain their condition, but in this case the range of the voltmeter and ammeter will need to be altered in proportion to the smaller current and higher volt-drops experienced. If the instruments are accurate and the readings carefully taken the figures obtained by the drop test can be converted into actual readings of resistance in ohms of the coils under test, since the voltmeter reading divided by the current in amperes represents the resistance of the circuits in ohms.

The Treatment of Faults

Having definitely established the presence and the nature of the fault by the means just described, steps can be taken to effect a repair or obtain a replacement part. And here it may be repeated that it is often scarcely worth while attempting repairs when a standard spare part is quickly obtainable. This applies particularly to armature windings. By the time a suitable " former " has been designed and one or two trial coils wound off to get the correct shape the time-sheet will probably show that expenses have mounted up to more than the maker's price for a new armature entire.

There are, of course, instances when no standard spares are available, or cost is a secondary matter to getting into running order quickly; but it should be clearly understood that armature winding is a highly skilled job and one requiring experience, especially when dealing with heavy gauges and strip windings.

Field coils are a different matter and can readily be dealt with on the spot. Whenever a field coil gives an unsatisfactory drop test it should be replaced with a new one. Floating faults which come and go are not usually worth spending the time in tracing out. A good drop test, for instance, on a cold coil may become definitely bad when the coil has become hot and expanded. Coils that have become soaked in oil especially ought always to be replaced with new ones.

Field-coil Repairs.—The first thing to do when renewing a defective field coil is to weigh it, gauge the wire, and note its covering. If the gauge is not too small or the turns too numerous, it can be unwound and a count of the turns also taken for check purposes, but the exact number of turns is of secondary importance to repeating the exact gauge of wire. If a count of turns is decided upon, mount the coil on a wood block chucked between lathe centres with a Veeder counter on the lathe head, and the wire can then be run off on to an empty reel. Counting should always be done automatically.

Except for heavy gauges, field coils are machine-wound. Cotton- and silk-covered wires are less common than formerly, and most field

coils in gauges between 20 S.W.G. (standard wire gauge) and 36 S.W.G. can be wound with enamel-covered copper, if some "cushioning" is provided between the layers to protect the enamel from being cut through under pressure from heat expansion. A special thin varnished paper or cotton interweave is usual practice in this respect. Cotton interweaving can be especially recommended as it makes the coil self-supporting, that is, it requires no bobbin or supplementary cheeks to prevent it from collapsing when it comes off its "former." The diagonal interweave of the cotton thread holds the wire in place until it has been impregnated and taped up ready for assembly.

Hand-winding is much too tedious an operation for fine gauges, the layers being far more even and closely packed if wound on a special winding machine. Such a machine is illustrated in Fig. 377, and a special attachment which can be adapted for self-supporting cotton-interweave coils in Fig. 378.

Armature Repairs.—Coming now to armature repairs, the first question is whether to repair or to replace. Circumstances must decide this, and if the former course is to be pursued the next step is to decide whether to renew the defective coil or coils or to rewind entirely. If one or more coils are definitely burnt out and show signs of blackened and charred coverings, the chances are that the heat developed in the process has also damaged other coils lying below them, and a total rewind is then the only satisfactory course. It occasionally happens, however, that one or more wires of a coil get damaged or cut through by a tool or some hard substance dropped across the end windings, and that although sound otherwise the damaged coil needs replacing.

Modern armatures are "former-wound"—that is, all coils are of the same size and shape, and wound upon the same former; one side of each coil lies at the bottom of a slot, the other side lies at the top of another slot, the ends taking an involute twist so that they lock into one another. In an armature designed to run in two-pole fields the two active sides of any one coil lie in slots on approximately opposite sides of the armature core, hence when dealing with a repair all the upper sides of the intermediate sound coils have to be lifted out of their slots before the underside of the defective coil can be removed and another replaced. Great care is needed not to damage the sound coils in this process, especially as they are probably wedged in pretty solidly and held with the insulating varnish. In fact the armature should always be warmed up first to make the varnish more flexible, and even then the attempt to remove the sound coils often results in further damage being done.

Stripping the Armature.—If this misfortune has occurred, before stripping the armature completely, take exact particulars of the following points:

(1) The number of slots spanned by each complete coil.
(2) The number of turns per coil.
(3) The gauge of wire.
(4) The covering on the wire.

(5) The position of the coil in relation to the two commutator bars to which its ends are attached.

The last is most important. If one coil can be got off the armature without distorting it too much it serves as a useful guide in shaping the wood former on which the new set of coils will be wound.

Former Winding.—In general the former is lozenge shaped, such as shown in Fig. 379. It is made up from a hard wood or fibre centre with removable cheeks slotted on each side so that string can be threaded through and the coil tied at four points to keep it in shape when removed.

The armature slots should be lined with new leatheroid or presspahn channels before rewinding, as the old ones will be brittle and unreliable. One side of each coil is placed in each slot first and then the opposite side

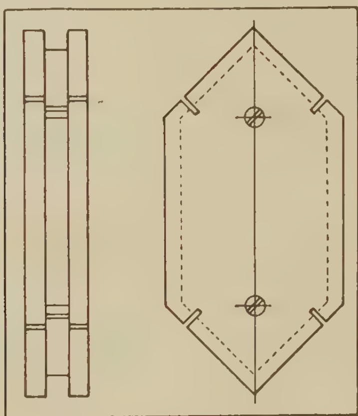


Fig. 379.—" Former " for Winding Armature Coils.

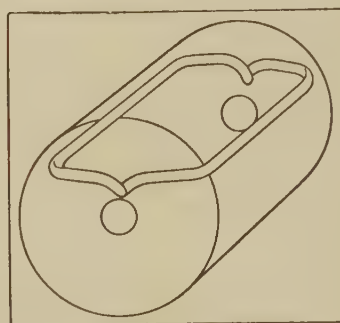


Fig. 380.—Former Armature Coil in Position.

brought down into its appropriate slot, giving it a half twist at the ends so that it turns more or less radial to the shaft (Fig. 380).

Coil Span and Connections.—The span of the armature coil must be approximately the same as the pole pitch of the fields. In a two-pole field this is 180°, and in a four-pole field 90°. Slightly shorter or longer spans do not materially affect the performance, and in practice a shorter span is often chosen, as it reduces the length of the end windings and facilitates coil assembly. The finish of each armature coil in a lap-connected armature is attached to the commutator bar next to the one at which it started, together with the start of the next coil; each section of the winding thus steps one segment forward until the last coil end joins up with the start of the first coil laid down, making a completely closed ring of the windings, all coils being in series with one another. Every commutator bar will then have two coil connections. If the original method of taking down the connections to the commutator has been followed exactly no further trouble ought to be experienced, but in case the original connections were destroyed or lost sight of there is a definite rule for ascertaining them.

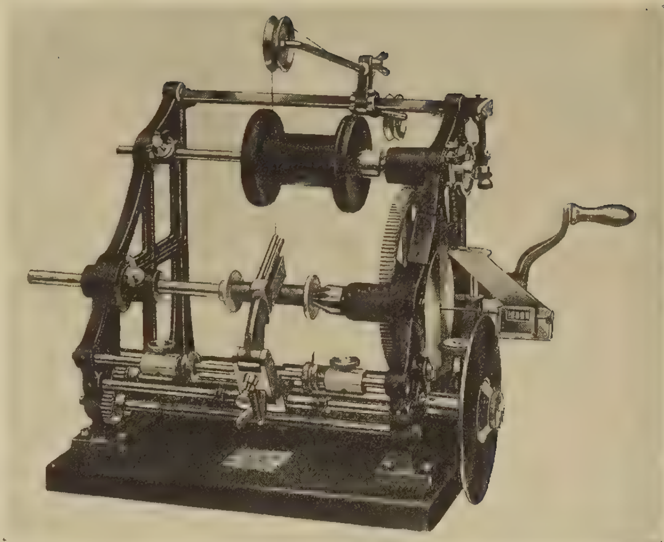


Fig. 377.—Coil-winding Machine for Field Coils. (Automatic Coil Winder Co.)

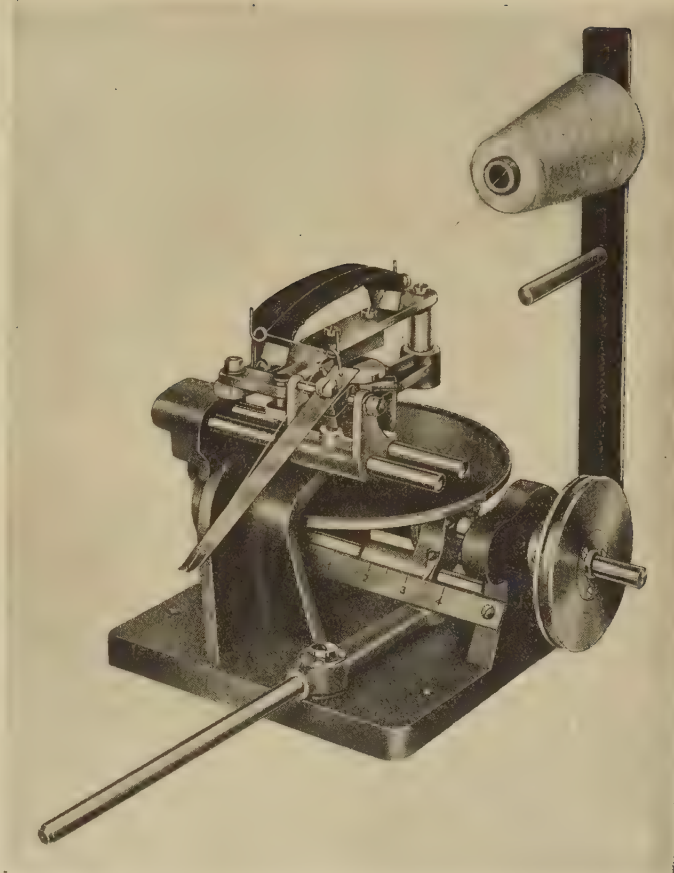


Fig. 378.—Cotton Interweave Attachment for Coil-winding Machine. (Automatic Coil Winder Co.)

Commutator and Coil Connections.—The principle to observe in setting out coil connections to the commutator for lap-wound armatures is first to place one coil in such a position that its two active sides in the slots are momentarily " sliding " along the direction of the magnetic lines from pole to pole, or in other words are midway between any two pole-tips. The starting and finishing ends of this coil are then attached to the two adjacent commutator bars lying on either side of the centre line of the nearest main brush (Fig. 381).

After assembly of the coils, they must be securely fixed in the armature slots by presspahn wedges pushed in under the overhanging teeth, or by binding bands of tinned steel wire sunk into recesses in the core stampings and soldered. Binding bands are also usual over each end winding; so much depends on the design of the armature and the extension of its end windings that the safest plan is to carefully observe and repeat the original method of securing the coils.

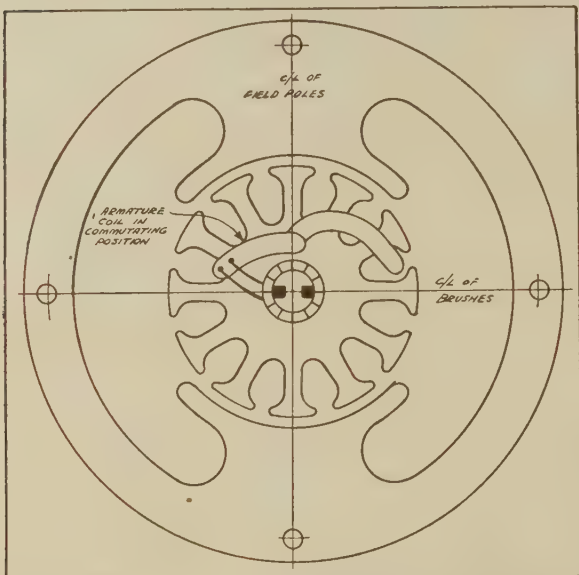


Fig. 381.—Armature Coil in Neutral or Commutating Position.

Doping.—The last operation after soldering up is to thoroughly dry out the armature in an oven and then immerse it bodily in a good insulating varnish, such as " Armacell " or " Ohmaline," after which six to eight hours' baking at a temperature of 180° F. is necessary to prevent the varnish throwing when at work. Finish off with an oilproof coat of Pakyderm varnish.

Field coils require drying out and doping in a similar manner, this being one of the most important steps in the whole process of coil repairs, whether for dynamo, starter motor, ignition coil, or magneto.

Magneto Testing.—The repairs which can be carried out to high-tension magneto and ignition coils are rather more limited than is the case with dynamos and starter motors; the main thing is to be able to locate definitely and accurately the nature and position of the fault when present. With this object in view special testing devices have been designed, one of which, by Messrs. V. L. Churchill, Ltd., is illustrated in Fig. 267, p. 261. This, as applied to magneto armatures, works on the inductor principle, the essential parts being an iron core in the form of a section of a ring fitted

with an energising coil fed with alternating current from the mains. In series with this is another small coil which operates an interrupter at the same frequency as the reversals of current in the main A.C. supply, usually 6,000 per minute. An E.M.F. is thus induced in the primary winding of the magneto armature by the fact of its being situated in the alternating flux of the tester core, providing an almost identical reproduction of the actual working conditions when the armature is revolving between its own poles, although now stationary.

A stabilised three-point spark gap of the type previously described is provided, adjusted to such length as to represent conditions similar to those under compression, and if the magneto is in good condition a spark 7 to 9 millimetres in length is obtainable between the points. Failure to secure this performance may indicate either an open-circuited winding, a defective contact breaker, or a short-circuited or disconnected condenser. The latter will be distinguished by excessive sparking at the interrupter contacts. A break in the windings would show up by failure to get any reading on a volt-meter when applied between core and collector ring with a battery in circuit. A weak spark at high speeds is generally an indication of weak magnets.

Magneto-armature Repairs.—An open-circuited secondary coil may still continue to spark when on service for a time, the spark jumping across the break internally, but the presence of any such fault would be detected by applying the continuity test above.

It is seldom a primary breaks down, but any fault in the secondary means stripping down the windings at least as far as the end of the primary, as no reliance can be placed on any part of the secondary once any fault has developed in it. Rewinding a secondary needs peculiar care and many precautions with the insulation. As the voltage piles up with each succeeding layer of wire an increasing thickness of insulation between iron core and windings is vital, or the spark will flash through the sides to earth, especially in the absence of a safety spark gap. This insulation is carried out by covering each successive layer of wire with a strip of 3-mil varnished silk cut wide enough to turn up the sides of the winding channel in the form of a deep flange. With each progressive layer this builds up increasing thicknesses at the sides of the cheeks where most vulnerable to breakdown. The winding itself is not wound right out to the cheeks, but stopped short a little way in on either side, the spaces increasing with added layers. The excess insulation is folded over the top of the final layer, finished off with a few turns of stouter wire for connection to the collector ring, and served with fine string over the top layer.

Machine winding is, of course, needed when dealing with such fine gauges as used in magneto armatures, and the winder illustrated in Fig. 377 is suitable for such purposes, as well as for dynamo field coils.

Condensers.—Condensers should be completely renewed if faulty; no attempts at repair are likely to do more than accentuate the trouble.

Contact Breaker.—The renewal, adjustment, and setting of contact points is too well known to need more than passing references, but it is sometimes overlooked that misfiring, especially at high speeds, can arise from the rocker-arm pivot sticking or sluggish action of the spring. Exact information as to this condition is best obtained by use of the stroboscope, which in its simplest form consists of a 12-in. disc of thin metal with a $\frac{3}{16}$-in. wide slit cut in it radially and fixed to a hub on the end of the shaft of a variable-speed motor. If the contact breaker is run at normal speed and viewed through this stroboscope disc rotating at exactly the same speed the arm will appear stationary. If the stroboscope-disc speed is increased or decreased the rocker arm will be seen to go through its cycle of operations more or less slowly, according to the differences in the relative speeds, giving a slow-motion picture revealing its exact behaviour, and the trouble, if any, successfully analysed and dealt with.

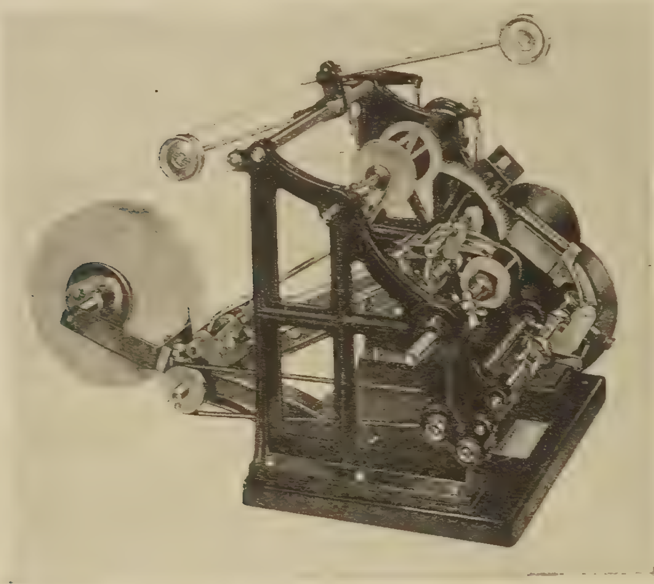


Fig. 382.—Coil-winding Machine for Paper Insertion between Layers. (Automatic Coil Winder Co.)

Wear of the cams is another point sometimes neglected, leading to irregular timing of the spark. This is only to be detected by the use of the rotary spark gap, in which the angular interval occurring between successive sparks is measured on a scale, with the magneto running at constant speed.

Ignition Coils.—Faults in ignition coils are in general not repairable, the primary winding usually being external to the secondary and the sealing-in compound in the casing being very difficult to remove without damage to the insulation or wire; this makes replacement preferable to repair. When a complete rewind is the only available course to pursue from stress of circumstances, the work proceeds much on the same lines as in the case of magneto armatures, and the precautions with insulation are similar. The primary and secondary windings are counted and gauged when stripping, and these particulars repeated. Rewinding can be carried out on a machine of the type shown in Fig. 382, but in this case it is arranged

with an attachment for automatically feeding varnished paper strip in between the winding of successive layers. Cotton interweave is not advisable for such high-potential work.

Crypton Garage Electrical Test Bench

It is a matter of much convenience, time and cost saving to employ a single electrical test bench for routine testing of automobiles, instead of having a number of separate pieces of equipment scattered about the garage or service station. In this connection the Crypton bench, illustrated in Fig. 383, was designed especially to provide in a single unit everything needed for testing dynamos, regulators, starters, distributors, and magnetos.

The model illustrated incorporates many new features over earlier apparatus devised for a similar purpose, with the object of simplifying test procedure and speeding up routine testing of electrical equipment. It caters for either 6- or 12-volt British or U.S.A. car equipment. With this plant the electrical system of any passenger car can be reproduced as regards load and speed characteristics and tests made under "service" conditions.

The test bench is fitted with a 2-h.p. motor giving speeds from 100 to 6,000 r.p.m. and dynamos can be either direct coupled or belt-driven. It has a self-aligning vice, shown at M, for easy horizontal clamping of dynamos, starters, or magnetos.

Dynamos can be tested and adjusted under load and if required at speeds in excess of the operating ones, thus ensuring a good factor of safety and providing tests of balance and commutation.

The Master Switch E automatically changes all testing instruments and controls for either a 6-volt or a 12-volt system.

Voltage regulators can be tested and adjusted under normal operating conditions and all makes (Lucas, C.A.V., Delco-Remy and Auto-lite) dealt with.

Starting motors can be tested for torque, starting current, and voltage.

Magnetos can be tested at all operating speeds by means of the rotary and annular static spark gaps shown at G and F, respectively, in Fig. 383.

Distributors can be tested over the engine speed range; the automatic advance operation can also be checked by means of the rotary spark-gap divisions.

The test bench is provided with continuity test leads and lamp, voltage test leads and sockets, tachometer, ammeter (calibrated 10–0–40 amps. and 200-0-800 amps.), voltmeter (0–20 volts), ammeter and voltmeter switches, dynamo field switch, transformer (to supply 50 volts A.C. for continuity or insulation testing), field rheostat, load rheostat (40 amps. capacity), starter and transformer switches, rotary spark gap and annular spark gaps (8-way type for magnetos and coil-ignition units.)

A larger model of the electrical test bench, known as the Crypton Super Service Bench, is available for large garages and service stations for fleets

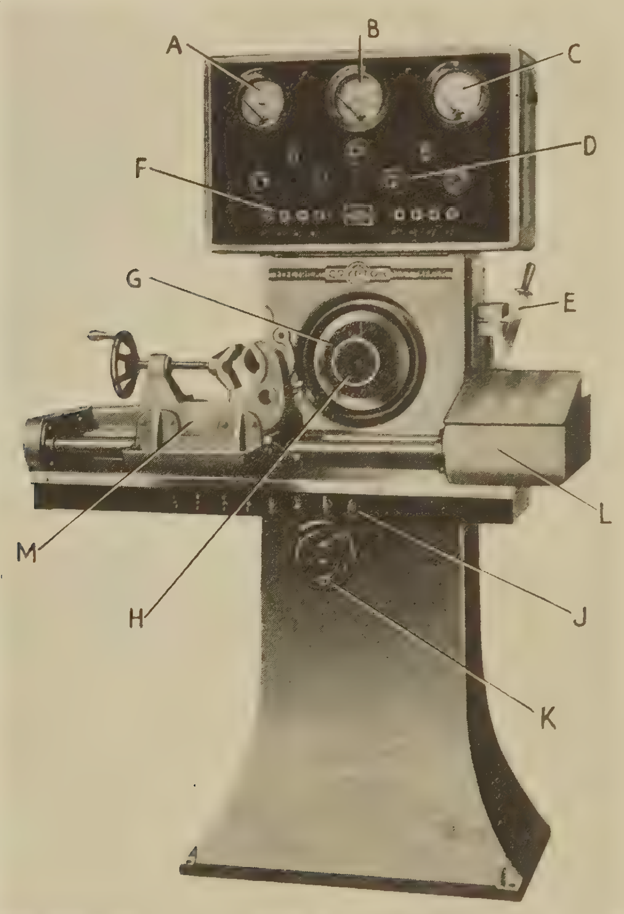


Fig. 383.—The Crypton C.12 Garage Electrical Test Bench.

A—Moving-coil ammeter. B—Electrical tachometer. C—Moving-coil dual-scale voltmeter. D—Control switches for 6- and 12-volt equipment. E—Master switch. F—Multi-way 8-point static spark gap for testing 4-, 6- and 8-cylinder ignition equipment. G—Rotary spark gap for accurately testing operation of automatic advance mechanisms. H—Electric motor drive for test bench. J—Terminals for test purposes. K—Handwheel for adjusting speed and direction of rotation of driving motor. L—Compartment for tools, etc., with sloping desk cover for reports. M—Vice for motors and dynamos, etc.

of vehicles, etc. It has a motor of 5 h.p. giving speeds from 250 to 6,000 r.p.m. and will precision test ordinary and heavy commercial- and passenger-vehicle electrical equipment of all types, including dynamos, starting motors, regulators, coil-ignition equipment, magnetos, etc.

A Portable Universal Tester

A portable electrical testing equipment produced by Messrs. Runbaken Ltd., Manchester, and illustrated in Fig. 384 enables a range of electrical tests to be carried out. It includes a hand-operated generator with two alternative speed ranges, namely, 0–1,500 r.p.m. and 1,500–6,000 r.p.m. and it can therefore be used for automobile electrical tests with the engine stationary, and for ignition tests from slow to very high speed conditions.

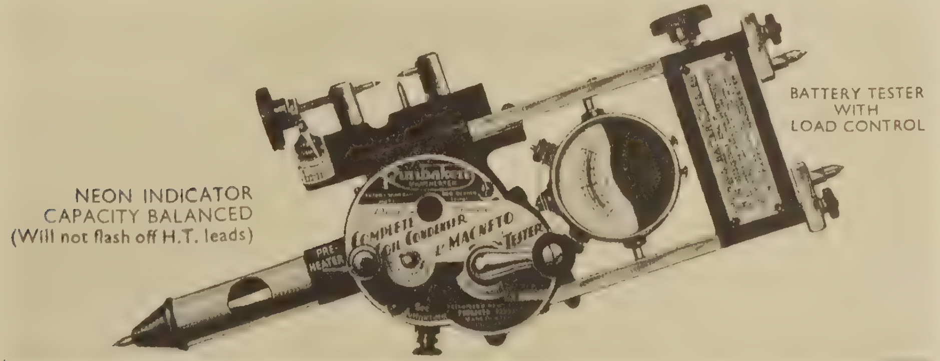


Fig. 384.—The Runbaken Portable Universal Tester.

It embodies a pre-heater for H.T. coils, as it is known that " cold " tests do not always show up certain faults which develop when the coil is warmed up to under-the-bonnet conditions.

The equipment embodies a standard 3-point spark tester for coils and magnetos; a neon indicator of the capacity balanced type and a car battery tester with pre-loading resistance and multi-scale ammeter-voltmeter.

Tests may be made on the L.T. ignition wiring, coil, condenser, rotor, H.T. wiring, the contacts, sparking plugs, magneto armatures, and starter. It is claimed that a complete electrical test can be made in about 8 minutes with this tester. The same unit can be obtained without the battery tester shown on the right in Fig. 382.

CHAPTER II

AUTOMOBILE BATTERIES

THE maintenance and charging of accumulators forms one of the chief items of regular profit to the garage engineer; it is also a beneficial practice for the private owner to be able to undertake the care and charging of his own accumulators. With the advent of wireless receivers, another branch has been added to the ordinary one of motor-battery charging, so that it is in the interests of the garage engineer and stockist to make himself thoroughly acquainted with the essentials of battery maintenance and charging.

Types of Accumulators

The two important types of secondary cells or accumulators with which the automobile user is concerned are the *Lead-Acid* and the *Nickel-Iron* types. Both types depend for their action upon the application of an electric current supply to two kinds of plates or electrodes immersed in a chemical solution. These plates are termed the *Positive and Negative* electrodes, and the solution the *Electrolyte*; the initial composition of each plate determines which is the positive or negative one. In effect, the process of charging an accumulator, by passing current from some other source through it, is equivalent to the storing up of chemical energy in the accumulator, this energy being liberated when the supply is withdrawn and the two electrodes connected (with a suitable resistance in circuit, so that too rapid a discharge cannot occur).

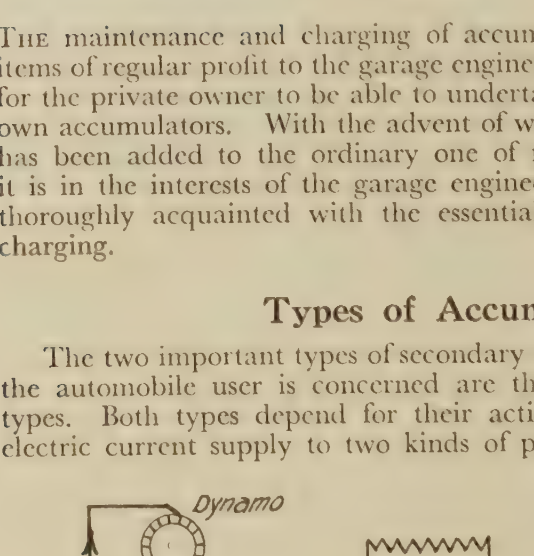


Fig. 385.—Illustrating the Action of the Lead-Acid Accumulator.

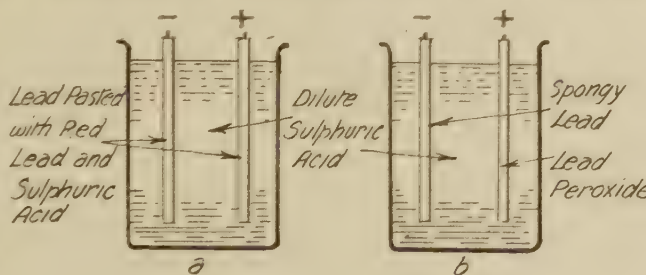
The simplest type of accumulator (Fig. 385) consists of two plates of pure lead immersed in dilute sulphuric acid (H_2SO_4). When an electric

current is passed through the solution, as shown in Fig. 385 (*a*), lead peroxide (PbO_2) is formed on the positive plate (or anode), whilst the negative plate (or cathode) remains unaltered.

If after a certain time the charging dynamo is taken off and the electrodes are connected together through a suitable resistance (Fig. 385 (*b*)), a current will flow through the cell, but in *a reverse direction* to the charging current. This is *the principle of the secondary cell*, or accumulator.

In order to accelerate the process of *forming* the plates so as to obtain a greater output in a very much shorter time, M. Fauré, a French scientist, coated the lead plates with a paste of *Red Lead* (Pb_3O_4) and sulphuric acid, the two reacting so as to give *Lead Sulphate* (Fig. 386 (*a*)).

On charging a cell composed of two such plates immersed in dilute sulphuric acid the positive plate becomes oxidised to lead peroxide (PbO_2) and the negative plate to *Spongy Lead* (Fig. 386 (*b*)). In order to make the paste adhere to the plates—a difficult matter to the early battery experimenter—it was found better to make the original lead electrodes or plates in the form of a grid or lattice-work, into the interstices of which the paste is pressed. The modern accumulator follows the original practice of M. Fauré, but employs a mixture of *Litharge* (PbO) instead of red lead—and sulphuric acid for the paste.



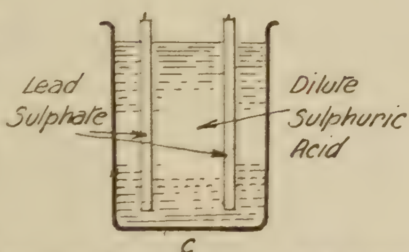


Fig. 386.—Showing (*a*) Formed Plates before and (*b*) after Charging. (*c*) After Discharge.

When the cell is charged, as before, the positive plate becomes coated with lead peroxide, and the negative with spongy lead. There is another type of lead-acid cell known as the *Planté* one, and of which the Exide is a good example. In this type the active material is produced from the surface of the plate itself by electro-chemical action. It is also subject to many modifications in construction, the chief difference being between the "formed plate" which is cast and formed and the "built-up plate"; the latter is largely used on electric vehicles of the heavier classes.

When an accumulator is discharged by connecting the electrodes through a suitable resistance the lead peroxide (PbO_2) becomes reduced to lead oxide (PbO), and then to lead sulphate ($PbSO_4$) (Fig. 386 (*c*)). The negative electrode also becomes converted (superficially, as it were) to lead sulphate.

The Voltage of Lead-acid Cells

Lead-acid accumulators when fully charged give a voltage, on open circuit, of 2·2 volts per cell, afterwards falling to a steady value, 2·1 volts. By connecting a number of cells in series, that is to say, by joining the positive of one to the negative of the next, and so on, the total voltage is increased, and is equal to the number of cells multiplied by 2·1 volts.

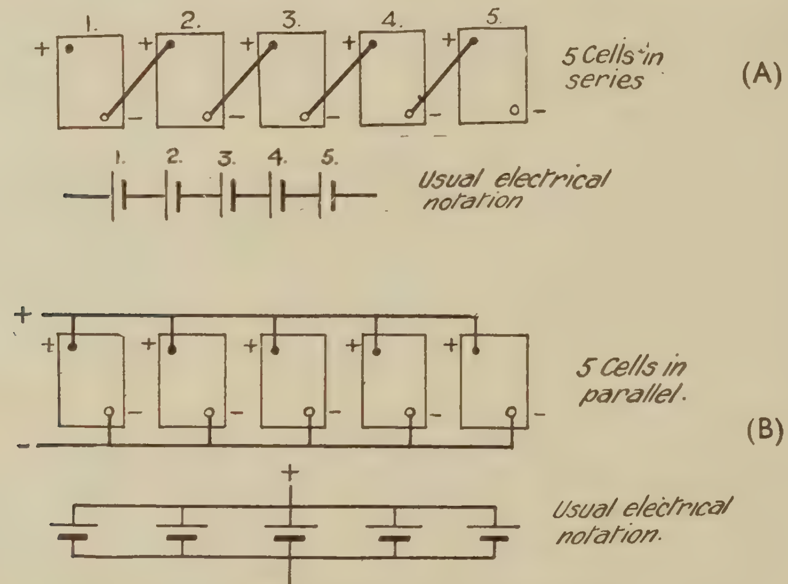


Fig. 387.—Cells Connected in Series and in Parallel.

Thus if six cells are joined in series, the total voltage is 6 × 2·1, i.e. 12·6. By joining all the positive plates together, and all the negative ones together, we get, as it were, a large-capacity cell having a plate area equal to the sum of all the separate plate areas, but the voltage remains at 2·1. We can therefore distinguish between series and parallel connections as follows:

Series Connection (Fig. 387 (A)).—Capacity equal to that of one cell. Voltage equal to sum of cell voltages.

Parallel Connection (Fig. 387 (B)).—Capacity equal to sum of cell capacities. Voltage equal to that of one cell.

The Capacity of a Battery

By *capacity* is meant the total discharge current which can be taken, safely, from a charged cell, and the time, or number of hours, over which it can be taken. Actually the capacity is expressed by the product of the safe discharge current and the number of hours of useful discharge.

Thus if a battery gives a steady current of 2 amperes for 20 hours without the voltage falling below 1·8 per cell, it is said to have a capacity of 2 × 20, i.e. 40 ampere-hours.

Capacity and Rate of Discharge.—The *practical capacity* of a battery depends upon the *rate of discharge*. Thus if a battery is discharged at a relatively high rate, or current, it will show a smaller capacity—as denoted by current × amperes—than one discharged at a lower or normal rate. For this reason battery manufacturers usually specify the number of hours or *rate of discharge* when stating the capacity of a given battery. Thus it might be specified that the capacity of a certain battery is 72 ampere-hours at the 10-hour discharge rate. This shows that a current of 7·2 amperes could be obtained for 10 hours from such a battery.

The capacity depends upon a number of factors, namely the size or areas of the plates, the density of the electrolyte, the temperature of the electrolyte, age or condition, etc.

The equivalent capacity, as previously stated, depends upon the rate of discharge. Thus an 80-ampere-hour battery at the 10-hour rate would give the following results at the other charging rates mentioned.

CAPACITY OF BATTERY AND DISCHARGE RATE

Rate or Time of Discharge (hours) . .	¼	2	5	10	20
Current Value Over Rate (amperes) . .	112	26	14	8	4·6
Equivalent Capacity in Ampere-hours . .	28	52	70	80	92

It will be observed from these figures that the shorter the discharge period the lower will be the effective or equivalent capacity of the battery.

A battery which is used intermittently will show a larger working capacity than one which is used continuously. For this reason manufacturers usually state whether the capacity claimed is for *continuous* or *intermittent* discharge; the latter is generally twice the former value.

Estimating the Capacity

If the capacity of a battery is not known it may be found approximately by multiplying the total area of the positive plates in square inches in each cell by two-thirds. Thus, if a battery has 6 positive plates, each of 4 × 3 in., the total area is 72, and two-thirds of this is 48, which is the ampere-hour capacity at the 20-hour rate of discharge. Another method is given on page 374.

The Acid Density

It is now recognised that the mere placing of a voltmeter across the terminals of a battery to show the state of charge of the latter is unreliable, for one can boost up a battery in a short time so as to give the full voltage —but it will not be properly charged. The more reliable test is that of the acid, for it is a well-established fact that the density of the acid of a fully

charged cell is from 1·250 to 1·300, this density falling progressively as the battery becomes discharged.

Automobile batteries are filled with acid of a density 1·270 to 1·320, according to type and climatic operating conditions. Practically all modern Lucas batteries are filled with acid of 1·320 density. Most C.A.V. batteries use the 1·320 density, but a few use 1·275.

Radio batteries generally use a density of 1·250; aircraft batteries use one of 1·270 to 1·285.

When *fully charged* the acid density is 1·280 to 1·300.

When *partly discharged* the density falls to 1·200 to 1·250.

When *totally discharged* the density usually reads 1·100 to 1·150.

It may be noted that when under load, i.e. with ignition and lights switched on, the *voltage per cell* is 2·15 to 2·20 for a fully charged battery and 1·150 or below for a discharged one.

Typical Battery Figures.—A typical example of a modern car battery, selected from a list of Lucas models, is the G.T.W.11A, as fitted to the Austin A90 cars. This is a 12-volt battery rated at 63 ampere-hours at the 10-hour discharge rate. The density of the acid for filling is 1·350. When the battery is fully charged, the density is 1·280 to 1·300. When half-charged it is 1·210, and fully discharged it is below 1·150. These densities are taken with the electrolyte at 60° to 75° F. The initial charge rate is 4·5 amperes and recharge current 7 amperes.

Charge and Discharge Curves

The best method of studying the properties of a lead-acid accumulator is to examine the curves which show the relation between the voltage of the cell at different periods of charging and of discharge. Consider a run-down or exhausted battery, which otherwise is in good condition, to be charged by means of a current from, say, a dynamo. Referring to Fig. 388 (upper curve marked "charge"), at first the voltage is 2·0, and during the first hour of charging it rises fairly rapidly to 2·2 volts; incidentally it will at once be evident why the voltage measurement of a battery is not a true indication of the state of its charge, for one can boost up the voltage in an hour or two to the correct value.

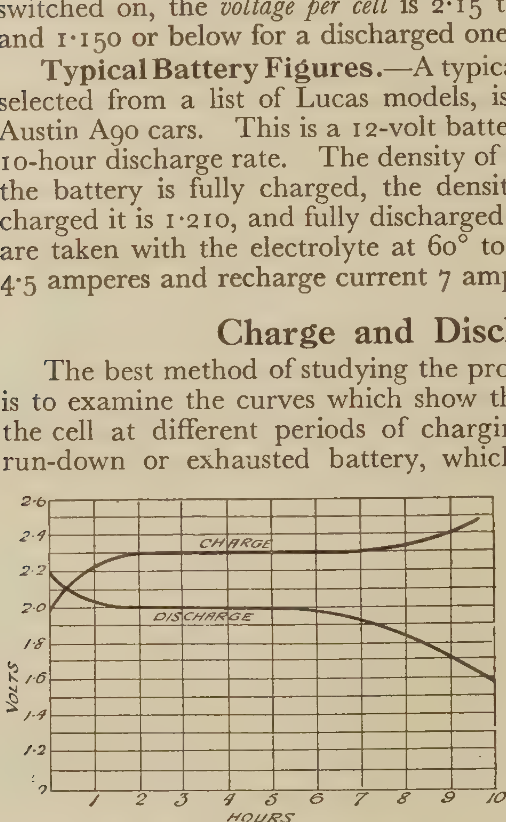
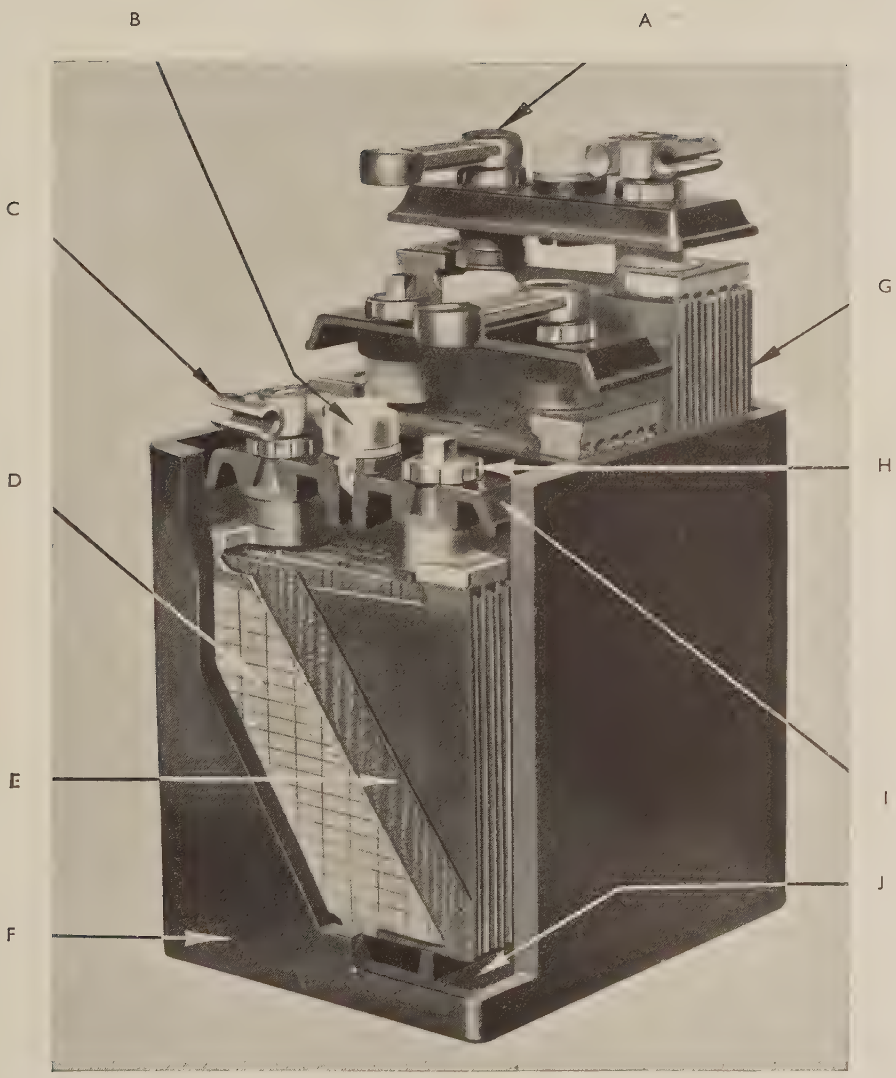


Fig. 388.—Typical Battery Curves.

For the next five hours the voltage remains constant, afterwards rising to a higher value. Upon disconnecting a freshly charged battery and leaving it standing for a few hours the voltage drops to about 2·1, the normal value.

Let us next consider the lower "discharge" curve of a battery which has its electrodes connected through a suitable resistance as in its ordinary



THE C.A.V. LEAD-ACID BATTERY, SHOWING INTERNAL CONSTRUCTION.

A, Lead Alloy Connector. B, Vent Plug. C, Standard S.M.M.T. Connector. D, Interlocking Grids on Plates. E, Threaded Rubber Separator. F, Moulded Container. G. Plate Sections. H, Sealing Nut. I, Sealing Groove. J, Sediment Chamber. Plates are supported on ribs in case.

duties. Immediately after charging the voltage is 2·2, but during discharge drops to 2·0, and remains steady for a time, after which it falls off fairly rapidly. The length of the straight part of the curve will depend upon the actual current value taken from the battery. In the example shown in Fig. 388 the current taken will be of a fairly high value; for lower currents the period of discharge as shown by the straight part is much longer, and is practically proportional to the current.

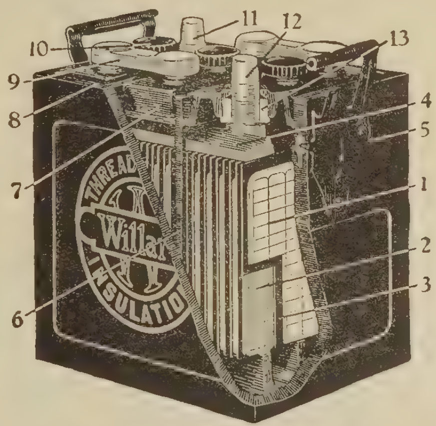


Fig. 389.—A Typical Storage Battery. 1, Positive Plate. 2, Negative Plate. 3, Separator. 4, Plate Connector. 5, Handle. 6, Cell Separator. 7, Top Filling Material. 8, Cover. 9, Bus-bar. 10, Filling Vent. 11, Conical Terminal (Positive). 12, Conical Terminal (Negative).

The Construction of Accumulators

The general principles of lead-acid battery construction are the same for practically all makes of battery, but the details and designs differ. It is essential for the garage engineer to make himself fully acquainted with the construction of batteries, since it may be one of his jobs to dismantle and repair them (Fig. 389).

The general construction of each cell consists of the outer or acid container, the positive and negative plates with their terminals and wooden or corrugated perforated separators between the plates to keep them from touching, but to allow the acid free access between the plates.

The plates are generally suspended from the tops of the containers and arranged that their lowest parts are at least ½ in. above the bottom of the container. This is to ensure that any sediment from the plates does not "bridge," or short them, thus causing a rapid discharge of the battery; this space below the plates is termed the sediment chamber.

The plates are fitted under a cover, in the container, to enclose the acid, prevent spilling and evaporation of the acid. The cover or top is usually run in with a pitchy compound in the case of automobile batteries, but a celluloid cover is used on wireless and similar batteries. It is necessary to provide filling collars, with suitable stoppers, and small air vents of the non-spilling type. Screw stoppers are probably the best in practice. Each 2-volt cell is joined in series by means of pure lead bars, fused on to the plate terminal stems solidly.

In the more recent batteries, ebonite or moulded composition containers are used to house the plates and also to form the container.

It is, as we have stated, necessary to provide *vents* in the filler caps or plugs. The reason is to let off the gases formed during charging, and to prevent any excessive pressures on the containers due to atmospheric-pressure changes.

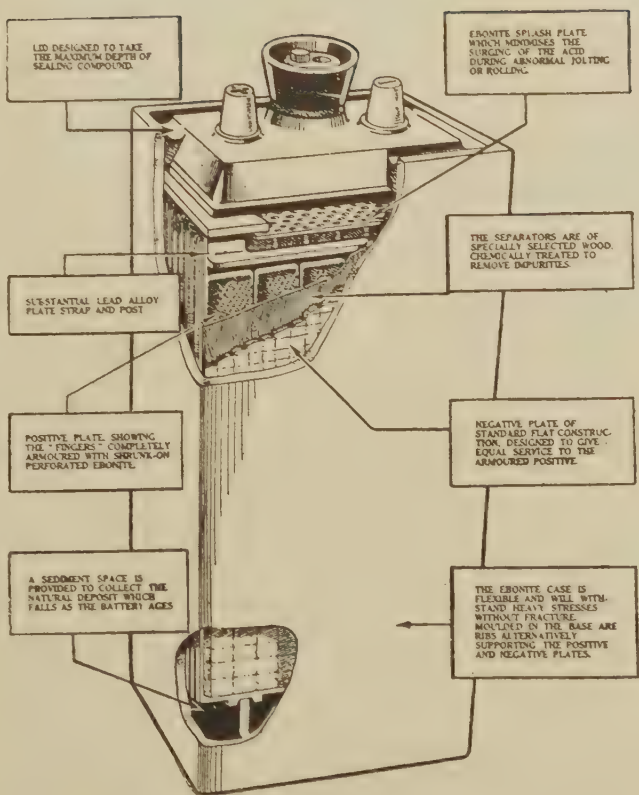


Fig. 390.—The C.A.V. Commercial-vehicle-type Battery, showing its Constructional Features.

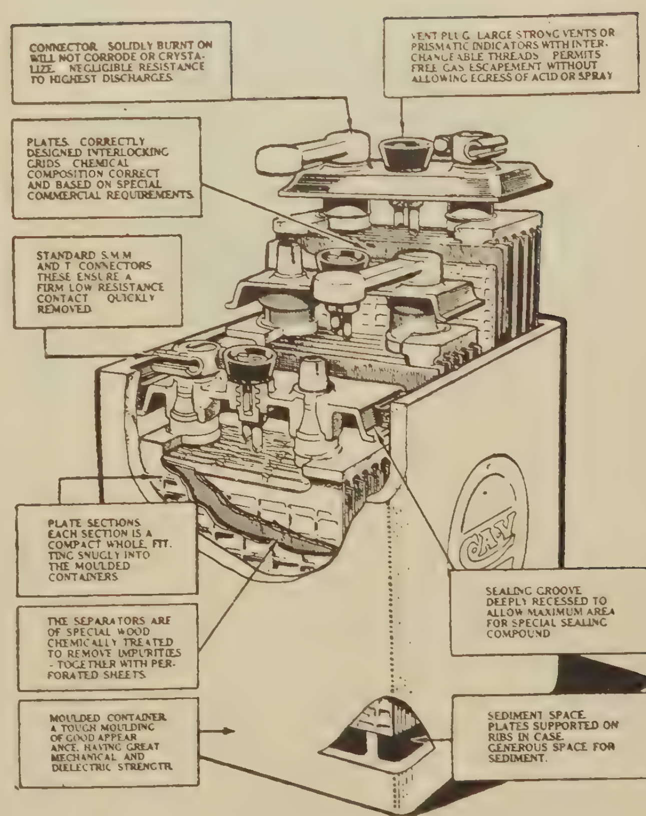


Fig. 391.—The Constructional Features of the C.A.V. Armoured Plate Battery.

Commercial-vehicle Batteries

The batteries used for commercial vehicles are of strong construction and will withstand the more arduous conditions of service better than those of ordinary motor-cars.

They are available in a range of capacities from about 50-ampere hours (at 10-hour discharge rate) up to nearly 300 ampere-hours, according to the size and type of vehicle.

The C.A.V. batteries comprise four groups, as follows: (1) Standard flat plate. (2) Heavy-duty flat plate. (3) Armoured plate and (4) Trolley-bus.

The general construction of the C.A.V. battery is shown in Fig. 390, the various internal and external items being indicated by the boxed lettering. A typical commercial battery of 105 ampere-hour capacity has 15 plates per cell and about $\frac{3}{4}$ pint of acid solution per cell. The initial charging rate is 6 amperes and the normal recharging rate 11·5 amperes. The specific gravity of the fully charged battery acid is 1·270 to 1·290. Under tropical conditions these values are reduced to 1·210 to 1·230 at 100° F.

The various characteristic features of the C.A.V. armoured plate battery are shown in Fig. 391.

Maintenance of Commercial Batteries.—Maintain the acid level at $\frac{3}{8}$ in. above the top of the plates by adding distilled water only.

If any of the acid is spilt, take care to replace it with acid of the correct specific gravity. The corrosive action of spilt acid may be neutralised by the quick application of an alkaline solution, such as ammonia.

Keep all terminals and fixing bolts spanner-tight and clean. All terminals and connections should be kept well smeared with mineral jelly or vaseline to prevent corrosion.

Keep the tops of the cells free from dirt and damp.

Should the battery be dismantled at any time for inspection or repair and the plates removed from the container, it is advisable to immerse the negative element in distilled water until ready for reassembling. If this element is replaced in the battery, the ordinary recharge rate will be sufficient to bring the battery into a normal condition. Should, however, the negative element be allowed to dry in the air before being replaced, or if a new negative element is used, then the battery will require the standard first charge rate for approximately 36 hours.

Do not attempt to lift the battery by the connectors between the cells or by the terminals.

Never examine the cells with an open flame.

Filling and Charging the New Battery

A frequent service for the garage engineer is that of charging new batteries. We shall not dwell here upon the charging equipment but rather on the charging procedure.

Most new batteries are now sent out in what is termed the *semi-charged state*, the plates being in the correct "formed" or chemical condition, similar to when freshly charged. It is then only necessary to fill up with acid of the correct density in order to put the battery into a condition ready for working. Actually, however, it is always advisable to let these cells stand for at least twelve hours, in order to allow the acid to soak into the interstices of the plates. (A freshly filled battery will show an appreciable drop in acid-level after a few hours.) A preliminary charging is always advisable with semi-charged batteries. The acid for filling is usually recommended to be of density 1·250 to 1·300—each maker has his own ideas on this point.

To mix up battery acid it is necessary to use pure or brimstone sulphuric acid (H_2SO_4) which has a density of 1·835 and distilled water—not tap or rain water. The mixing should be done in a glass or earthenware vessel—never in a metal one. Always add the acid to the water, and not vice versa, for a good deal of heat is generated in the latter case and the water forms steam and scatters the acid. Keep on adding acid, and after stirring and allowing to cool to about 70° F. take the density with an instrument called a *hydrometer*, until the mixture has the correct density value recommended by the makers.

The following table will be found useful when mixing sulphuric acid and water for batteries. It shows at once the correct quantities of the two liquids required to give battery acid of any desired density. The pure acid density taken is 1·835.

A USEFUL TABLE FOR BATTERY-ACID MIXING

Specific Gravity.	*Proportions, by Volume.*	
	Water.	*Acid.*
1·200	4⅓	1
1·225	3⅔	1
1·250	3½	1
1·275	2¾	1
1·285	2⅔	1
1·300	2½	1
1·335	2	1
1·350	1¾	1

It is very important to *allow the mixture to cool* before taking its density, as the latter varies appreciably with the temperature. Having filled the cells with acid, allow them to stand for at least 12 hours, as previously stated, and then give them a first charge at the normal current rate recommended by the makers for not less than 48 hours; the charging period may either be continuous or in periods of 12 hours, with intervals between. During the charging period ascertain that the cells do not become too hot; if any appreciable temperature rise is noted, reduce the current value; this will, of course, prolong the charging time.

Again, if the cells are found to be *gassing freely*, it is a sign that they are fully charged.

Just before the completion of the first charge it is recommended by the best authorities that the acid should be poured off and the cells refilled with fresh acid.

Density readings should be taken of each cell and if the density is not at the maker's correct figure (1·255 in the case of Exide batteries) it should be lowered by adding distilled water, or raised by adding acid-water solution of 1·350 density.

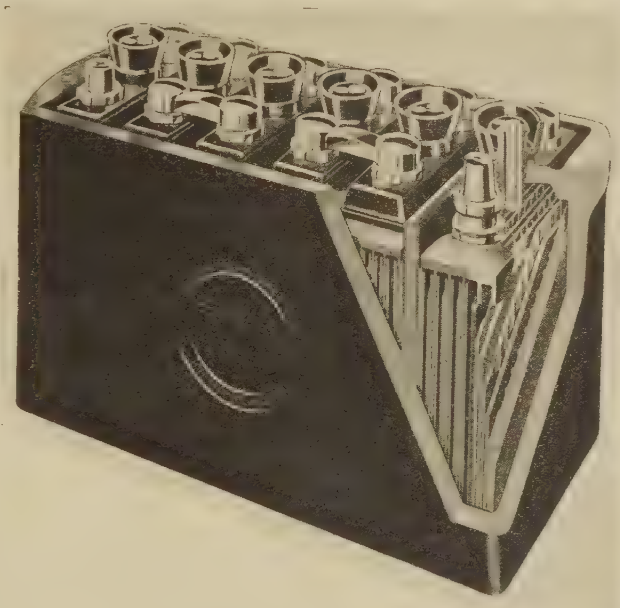


Fig. 392.—Partly Sectioned Lucas 12-volt Battery, showing special Acid-level Device (illustrated in Fig. 398).

This procedure should only be followed if the correct density is not obtainable by prolonged charging. Further, it should be carried out at the correct temperature, namely 70° F.

When "topping up" freshly charged new batteries add sufficient acid of correct density so that the level is about $\frac{1}{4}$ in. above the normal acid-level mark on the cells, for when the gas bubbles have been eliminated the level will fall by this amount to the correct value.

Many authorities recommend the *gradual discharge of a first newly charged battery* through a suitable resistance, such as a number of lighting-circuit bulbs, at a low current rate, namely from $\frac{1}{2}$ to 1 ampere in the case of a motor battery. The battery should be discharged until the density falls about midway, or perhaps a little lower, between its fully charged and fully discharged value, after which it should be charged up again.

This procedure of "*breaking the battery in*" leaves it in the proper condition for commencing its normal duties without fear of giving trouble or of deteriorating.

Normal Charging Procedure.—When a battery not of the automobile type is brought into the garage to charge, if it is of the glass or celluloid type, the plates should be examined visually for condition. Here it is useful to remember that in the case of a fully charged cell *the positive*

plate has a rich chocolate-brown colour—due to the oxide of lead, whilst *the negative plate is grey*—due to the spongy lead.

In a discharged cell the positive plates are much darker than before, and the plates seem inert or dead.

The density of each of the cells should at once be tested with the hydrometer, in order to ascertain the state of the charge. If the battery is right down, it may be due to buckled or broken-down plates, loose paste, or sediment shorting. If a cell fails to take a charge this is evidence of such a breakdown.

The cells being in apparently chargeable condition they should be filled above the normal level, *with distilled water* this time—not acid solution. In emergency clean rain-water or melted ice can be used, but *not tap water*.

The cells may now be placed on charge, the current through them being adjusted to the correct value stated by the makers. *This charging rate* varies in the case of the smallest cells from $\frac{1}{4}$ ampere up to as much as 10 amperes in the case of the largest ones.

Usual Charging Rates.—The correct charging rate will depend upon the type and capacity of the battery. In this connection the manufacturers issue tables giving the initial and recharging rates for each type of battery; these should be consulted.

For car batteries the initial charging rates, according to type, lie between about 3·5 and 4·5 amperes; in the larger car sizes rates up to 7 amperes are employed.

In commercial batteries initial rates usually lie between about 8 and 10 amperes, but in the largest sizes (C.A.V.) initial charging currents up to 20 amperes are recommended.

The normal re-charging rates are generally about 50 to 70 per cent. greater than the initial charging rates for new batteries. Thus in the case of a typical modern car battery having an initial charging rate of 4·5 amperes, the normal charging rate when in service would be 7 amperes. The dynamo regulator is set to give this normal rate, but with a greater current when the battery is " low " and a lesser rate, tapering off to a trickle charge of an ampere or two, when it is nearly fully charged.

If the charging rate of a battery is not known, it may be ascertained approximately by dividing the (actual) capacity by 12. Thus the charging rate for an 80-ampere-hour battery would be about 6·6 amperes.

Ascertaining the Charging Rate.—It is sometimes difficult to ascertain the correct charging rate, more especially in cases where the makers are unknown and there are no printed instructions on the battery case.

The following is a good approximate method to adopt in such cases, based on the fact that a well-made battery has a *capacity of* 1 *ampere-hour for each* 3 *sq. in. of plate surface*, and that the discharge rate should give a 20-hour period. Measure the total area of each plate (both sides); suppose this to be 24 sq. in.

Multiply this area by the number of positive plates. Suppose this number to be 6; then we have the product $6 \times 24 = 144$ sq. in.

Since the standard capacity is 1 ampere-hour for every 3 sq. in., for 144 sq. in. it must be $\frac{144}{3} = 48$ ampere-hours.

The actual charging rate for a 20-hour discharge is obtained by dividing the ampere-hour capacity by 12.

$$\text{Hence charging rate} = \frac{48}{12} = 4 \textit{ amperes.}$$

The Rapid-charge Method.—Tests have shown that batteries in good condition when discharged may be recharged using relatively high-charging rates without harmful effects. This is known as the " fast boosting " rate. Certain precautions, however, are necessary or the battery may be harmed. Thus whilst the initial rate for a 50- to 80-ampere-hour battery may be from about 60 to 90 amperes, this rate should be decreased to about two-thirds to one-half towards the end of the charge. The acid density should be checked, and when it is correct the charging must be stopped.

During this rapid charging process—which may take only 40 to 60 minutes—the temperature of the electrolyte must not be allowed to exceed 105° F., otherwise the battery may be damaged. The correct electrolyte density at 60° F. must be used for checking the state of charge.

The rapid-charge method is generally to be recommended as an *emergency measure* only, and should not be used instead of the normal charging-rate procedure. Further, this method must *not be used for the initial charging of a battery.*

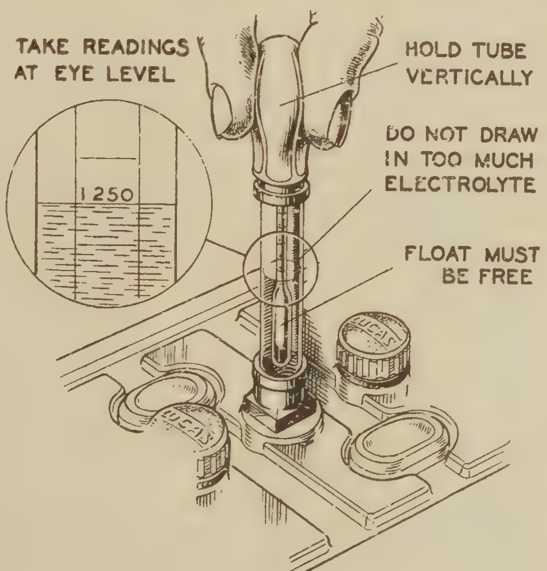


Fig. 393.—Using the Hydrometer (Lucas).

Hydrometers

These devices are made for the purpose of reading the densities of liquids, and they depend, in principle, upon the fact that if a solid, lighter than, say, water, is placed in the latter, it will float immersed to a certain depth in the liquid. The denser the liquid, the smaller the portion, or depth, of the immersed part in the liquid. Hydrometers are simply sealed hollow glass floats resembling thermometers, which are placed in liquids, to read their densities by the depths to which they sink.

The usual automobile battery pattern consists of an outer glass or cellulose-composition tube, having a small rubber tube at its lower end for inserting in the battery acid, and a rubber bulb over the upper end. When the latter is compressed, so as to partially expel the air inside the tube, and then released with the lower tube or nozzle immersed in the battery acid, the liquid is drawn up into the tube.

Now inside the transparent tube a small hydrometer is arranged, as shown in Fig. 393. This floats to a certain depth in the acid drawn up into the outer glass tube and graduations

Fig. 394.—The Coloured Ball Hydrometer.

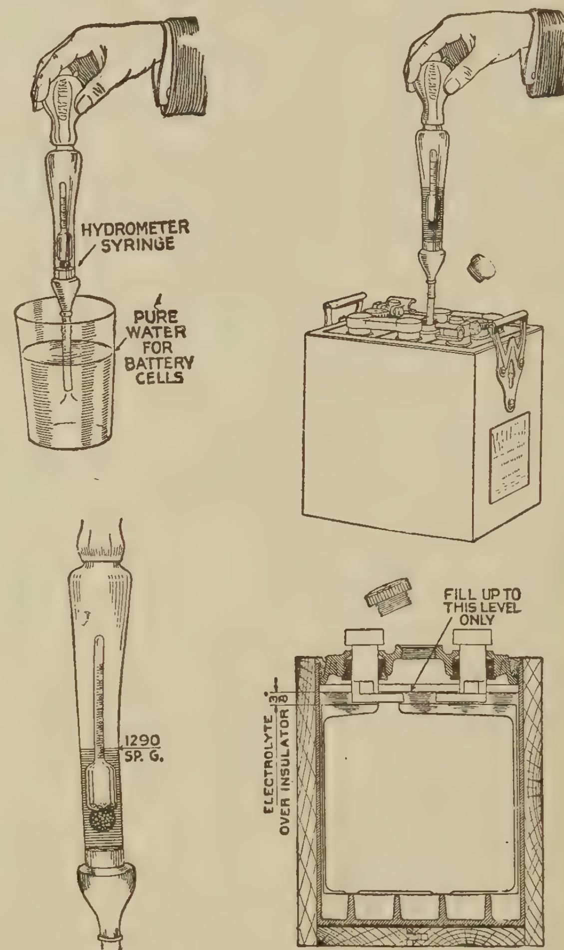


Fig. 395.—The Float Hydrometer and its method of use.

on the hydrometer stem enable the density to be read off. The reading is taken at the level of the liquid, as shown in the left inset diagram in Fig. 395.

Most hydrometers are weighted with lead shot inside in order to make them sink to the correct range of stem readings in the liquid for which they are intended.

In another popular kind of hydrometer (Fig. 394), instead of the usual

thermometer type of instrument, there are three balls of different densities inside the outer glass tube. These balls are coloured white, green, and red respectively. When the acid is drawn up, and its density indicates the correct charge, *the white ball sinks*. If, however, *the red ball sinks*, this shows that the battery is exhausted. If *the green ball sinks*, the battery is only partially charged. When all three balls float, the battery is fully charged.

On account of their fragility, glass hydrometers are often replaced by models having celluloid or cellulose-composition outer tubes.

How to Read the Battery-acid Density.—The following, briefly, is the proper procedure: First remove the vent plugs from the cells; compress the bulb of the hydrometer; insert the nozzle through the vent hole into the electrolyte (acid); release the bulb until a sufficient quantity of the acid has been drawn up to cause the hydrometer float to rise. Now hold the hydrometer in a vertical position, *so that the float does not touch the sides of the outer glass tube*, and read off the float scale on the level of the liquid in the tube.

It is important always to *run the liquid back* from the hydrometer *into the cell from which it was taken.*

Keep the Electrolyte at Proper Level.—In the case of batteries in service it is important to keep the electrolyte always at the correct level, usually about $\frac{1}{4}$ to $\frac{3}{8}$ in. above the tops of the plates, as shown in Fig. 395 (bottom right-hand side). For modern-pattern Lucas batteries the correct level of the electrolyte should be when the *top edges of the separator plates* are just covered. For C.A.V. batteries a similar level is recommended. Car batteries are often overcharged during summer months, or when used a lot in daylight, and water is lost by the gassing of the cells. In addition, evaporation is always proceeding, so that the liquid level is gradually lowered. If the tops of the plates are exposed not only are they liable to deterioration but the capacity of the battery is reduced in proportion to the amount of uncovered surface.

Always " top " the electrolyte—that is, all up to the proper level—by adding *not battery acid*, but *distilled water*.

If, however, any of the acid is spilt, replace it with acid of the same density as that in the cell.

In emergency, melted clean snow may be used for topping-up purposes, but not mains water. Clean rain-water in non-industrial areas can also be used in emergency.

Renewing Acid Periodically.—When a battery has been in more or less constant use for twelve months or more its acid should be emptied out, and any sediment washed out with freshly made acid solution or distilled water. The battery should then be refilled with fresh acid and recharged. It is better to first charge the battery fully, and then empty the acid out.

Temperature of Electrolyte during Charging.—When a battery is charged at a comparatively high current rate the electrolyte becomes

heated. The higher the charging rate the more it is heated. *The temperature* of the electrolyte *should never be allowed to exceed* 100° F. It should again be emphasised that density readings must be taken when the liquid has cooled to 60°–70° F. A small glass mercury thermometer of the dairy type should always be kept handy in the charging room.

The following table refers to the effect of temperature of the acid solution upon the specific gravity and it is arranged in the form of corrections to be applied to acid densities at 60° F., i.e. the normal air temperature.

If acid is at:

50° F.	deduct	·004	from	readings	to obtain	true	S.G.	at 60° F.
55° F.	„	·002	„	„	„	„	„	„
60° F.	„	—	„	„	„	„	„	„
65° F.	add	·002	to	„	„	„	„	„
70° F.	„	·004	„	„	„	„	„	„
75° F.	„	·006	„	„	„	„	„	„
80° F.	„	·008	„	„	„	„	„	„
85° F.	„	·010	„	„	„	„	„	„
90° F.	„	·012	„	„	„	„	„	„
95° F.	„	·014	„	„	„	„	„	„
100° F.	„	·016	„	„	„	„	„	„
110° F.	„	·020	„	„	„	„	„	„
120° F.	„	·024	„	„	„	„	„	„

Storing Batteries.—When it is desired to lay up a car the battery should not be allowed to remain idle in it without further attention; it should be removed and given a full charge and then recharged every 6 to 8 weeks.

A battery which has stood idle for more than two months should be charged at normal rate to maximum density before being placed in service.

The motor owner storing his car is advised to send the battery to a charging station to be kept in condition until required again.

Another method of storage, known as the "dry storage" method, consists in first charging the battery, and then draining out the electrolyte. If wood separators are used between the plates these should be dried and stored in a dry place. The battery plates should also be taken out and dried before storage. When the battery is again required it is reassembled, filled with acid, and charged again.

Threaded rubber insulated batteries should always be stored wet, that is, in the normal state, charging at six to eight weeks' intervals.

The owner-driver who finds it inconvenient to take his battery to a charging station for storage should run his engine (with generator in action, of course) every few days for about an hour at a time. If the carburettor is given as much air as possible, and the ignition well advanced, the amount of petrol thus used will be very small, and the cost of charging quite low.

How to tell when a Battery is Charged.—There are three alternative methods of ascertaining when a battery is charged, namely:

(1) *By the Colour of the Plates.*—When discharged, the positive plates are

darker than the negative ones. When fully charged the positive plate is a rich chocolate brown, and the negative one a grey colour.

(2) *By the Density of the Acid.*—When fully charged, and allowed to stand until the temperature falls to 70° F., the density of an automobile battery, as we have mentioned elsewhere, should be about 1·280 to 1·300, according to the make. Density readings should be taken about half an hour after charging.

(3) *By Measuring the Voltage.*—When fully charged, and allowed to stand for more than half an hour, the voltage value per cell is 2·6. This falls in a few hours to 2·1 volts per cell.

The total voltage of a battery is equal to the number of cells multiplied by 2·6 (when just charged). Thus, if there are six cells the voltage will be $6 \times 2{\cdot}6 = 15{\cdot}6$, falling in due course to $6 \times 2{\cdot}1 = 12{\cdot}6$.

When a cell is practically charged the electrolyte exhibits a gassing action, bubbles of oxygen and hydrogen rising to the surface continuously.

Batteries Used in Cold Climates

In this country it is seldom necessary to trouble about the possibility of the battery freezing, but it should be remembered that *a discharged battery has a density* (about 1·15) *only a little more* than that of water (1·00), and a corresponding freezing temperature of − 5° F., that is, equivalent to 37° F. below the freezing-point of water (+ 32° F.). A fully charged battery freezes at − 60° F. Freezing of a battery causes the paste to fall out of the grids, and therefore ruins the battery.

Another important effect of low temperatures is that the effective capacity or the chemical activity of the battery is reduced as the temperature is lowered, so that when using a starter battery in frosty weather the cranking effort is appreciably lower than in normal weather, irrespective of the condition of the engine.

Battery Faults and Troubles

The usual troubles experienced with batteries include the following:

(1) **Sulphation.**—This condition is indicated by white patches or areas on the plates, readily observable on inspection. This sulphation is caused by too rapidly discharging the battery, as by shorting the electrodes, by allowing the electrolyte level to fall below that of the tops of the plates, by using impure instead of distilled water, and by allowing the battery to discharge too far, and to remain discharged. A defective generator, which only partially charges its battery, will in time cause the latter to sulphate.

Sulphation is a chemical effect, resulting in the formation of white lead sulphate on the surfaces of the plates—the normal result of completely discharging a battery. This sulphate insulates the material of the plates from the acid, so that the latter cannot reach it. It is therefore impossible to charge a sulphated battery properly, or for the latter to " hold " a charge.

Sulphation, if not too pronounced, *can practically be cured* by charging the battery at a very low rate, namely about one-tenth to one-twentieth of the normal rate. This operation takes a long time, but it should be continued until the cells begin to gas freely. The battery should then be discharged very slowly through a resistance such that the discharge current is not greater than one-tenth of its normal value, say $\frac{1}{3}$ to $\frac{1}{4}$ ampere. Sulphated batteries should be repeatedly charged and discharged in this manner until the plates resume the correct colours and the voltage after charging is not less than 2·6 per cell. Badly sulphated batteries are difficult to cure, but some improvement may be made by washing out the cells, filling with fresh acid, and charging at a low rate. If the battery shows a full charge afterwards, empty the acid out and again fill with fresh acid, repeating the charging process.

(2) **Internal Shorting of Plates.**—This defect is indicated by a cell refusing to charge, so that after a certain period of applying the charging current it will not register any voltage. If after being on charge for an appreciable time the complete battery is tested for voltage and it is found that the full voltage corresponding to the number of cells is not attained, each cell should be checked for voltage independently until the defective one (or ones) is found. Failure to show voltage after prolonged charging may be due to one or other of two causes, as follows:

(*a*) **Buckled Plates,** in which case the plates are bent instead of flat, and the edges of adjacent plates touch. Excessive discharging of a battery will cause plate buckling, due to the effect of local heat development. Excessive charging current will also promote plate buckling due to relatively high local temperature effects.

The only cure for buckled plates is that of complete replacement.

(*b*) **Dislodgment of Paste.**—Batteries which have seen long service on motor vehicles, or have been badly handled, as, for example, by dropping heavily on the ground, are liable to this trouble. The active material of the plates, in part, becomes dislodged and either falls against the separators, thus forming a bridge between the positive and negative plate, or drops to the bottom of the container, in time building up to the level of the bottoms of the plates.

The positive plate is usually more liable to this trouble than the negative one.

Another cause of sedimentation and loss of active material is that of excessive charging, for the gassing which results tends to dislodge small particles of paste; sulphated parts of plates also tend to break off.

We have grouped the two types of material dislodgment together, namely sedimentation and loss of active material, since both belong to a common class.

The former defect is, however, in the case of batteries on cars largely caused by prolonged vibration and shock.

It is advisable in both cases to wash out thoroughly car batteries once

each year, making sure that all sediment or loose particles are got rid of. The cells should then be given a fresh filling with battery acid of the correct density and recharged.

Maintenance of Lucas Batteries

The following procedure is that recommended for the care and maintenance of Lucas motor-car and commercial-vehicle batteries.

Once a month, unscrew the filler caps and pour a small quantity of

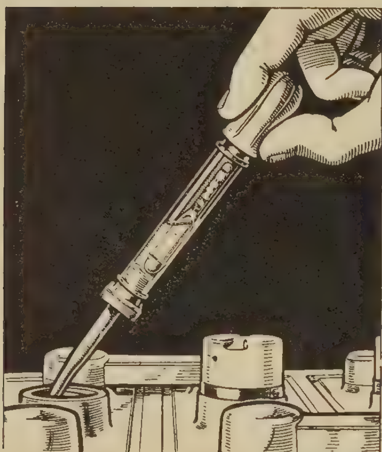


Fig. 396.—"Topping Up" the Lucas Battery Cells.

Fig. 397.—Keep the Car Cable Terminals Tight.

distilled water into each of the cells to bring the electrolyte just level with the tops of the separators.

Keep the terminals and battery-fixing bolts clean and well smeared with vaseline. *With earth-return battery systems* one of the terminals must be in good metallic contact with the chassis frame. When inspecting the battery, test the cable-connection bolt with a spanner.

Keep the outside of the battery dry, particularly the tops of the cells.

Water and dirt form quite a good conductor of electricity, and if such a path is allowed to form between the positive and negative terminals of the battery or between a terminal of the battery and the chassis, there will be a leakage of current which will cause the battery to run down. Give the cell tops a regular wipe over and you will avoid this.

Once a month take hydrometer readings from each cell.

The specific gravity readings and their indications, for Lucas types, are as follows:

1·250–1·300—Battery fully charged.

1·150–1·250—Battery about half discharged.

Below 1·150—Battery fully discharged.

These figures are given assuming the temperature of the solution is about 60° *F.*

The readings for each of the cells (there are six cells in a 12-volt battery, and three in a 6-volt type) should be approximately the same. If one cell gives a very different reading from the rest, it may be that acid has been spilled or has leaked from this particular cell, or there may be a short circuit between the plates.

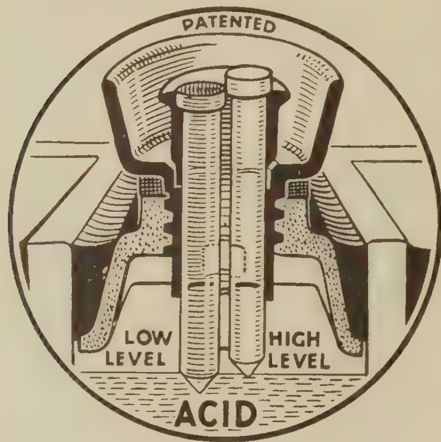


Fig. 398.—The Lucas Acid-level Indicator.

Never leave the battery in a discharged condition for any length of time. This is very bad for it. In a sense, it is like running a car on flat tyres. If the car is to be out of use for any length of time see that the battery is fully charged and about every fortnight give it a short refreshing charge to prevent any tendency to permanent sulphation of the plates.

Combined Acid-level Indicator, Vent Plug, and Filler Cup (when fitted).

The indicator consists of two small glass rods which project into the top of the cell (Fig. 398). When the acid-level is low the tops of both rods appear light. " Top up " the battery by pouring distilled water slowly into the filler cup until both indicators just go dark—then stop.

Checking Condition of a Battery

In the case of a battery of unknown condition it is recommended that it should be checked for acid density and then charged until the correct density corresponding to the fully-charged state is attained over a period of 4 to 5 hours. The battery should then be discharged through a resistance capable of taking the discharge current at the recommended rate of discharge, e.g. the 10-hour rate. The time taken for the density to fall to about 1·150 should be taken. This time when multiplied by the discharge current—which is assumed to have been maintained constant during the test—gives the ampere-hour capacity, a value which should be checked against the maker's figure. A quick test method is to subject the cells, in order, to a heavy rate of discharge by means of a short-circuiting resistance to give a current of 100 to 200 amperes. The voltage drop during this test affords a reliable indication of the battery condition, for this voltage varies in relation to the discharge current very closely, and any undue drop in value is a definite indication of the battery's unsatisfactory condition.

A particularly useful form of battery-testing appliance is illustrated in Fig. 399. This device has an insulated handle, with hoop for hanging it on a nail when not required. At its lower end is a pair of steel prods, one of which is adjustable to suit different battery-cell plate spacings. Across

the metal bars to which these prods are connected is arranged a combination ammeter and voltmeter, having a single dial, single needle, but a duplex scale for reading the volts and amperes.

It is thus possible to isolate a particular cell of a battery if it is defective, so that there is no necessity to open up the whole battery for inspection.

A load up to 200 amperes can be applied at the time of taking the test, and a small inspection lamp is provided which, in addition to lighting up the face of the meter, gives an indication of the state of the cell. This feature is particularly valuable inasmuch as it permits the garage engineer to point out the faults to a customer in a convincing way.

The method of using this battery tester is shown in Fig. 400.

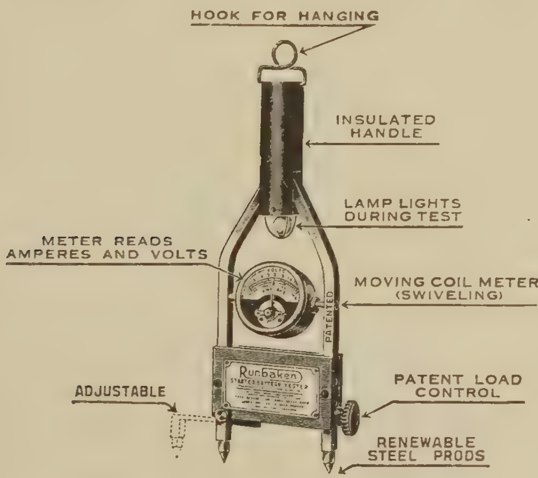


Fig. 399.—The Runbaken Battery Tester.

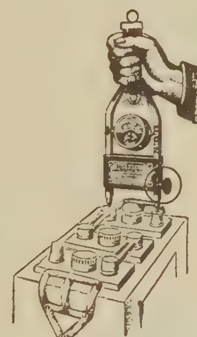


Fig. 400.— Showing Method of using Runbaken Battery Tester.

The Cadmium Battery Test.—An important method of testing motor-car batteries is that known as the " cadmium test." This serves as a final diagnosis on a *cell which is found faulty* and where neither the terminal voltage nor the acid density reveals the cause.

To understand the application of this test it is necessary to know the underlying theory which, briefly, is as follows:

When the cadmium electrode is in the acid, a layer of cadmium sulphate is formed on its surface, which is neither electro-positive nor electro-negative to the acid in the cell, so that voltmeter readings between cadmium and either set of plates give the potential due to the respective plates undergoing charge at normal rate.

A fully charged cell will show a reading (against cadmium) on the positive plates of from 2·35 to 2·50 volts and on the negative from + ·1 to + ·2, the negative sign showing that the potential is reversed, the algebraic difference of the readings giving the terminal voltage. The limits above given are due to the variations between different types of cells, and

for any particular cell the algebraic difference of the readings should correspond to the value given by the makers for a fully charged cell.

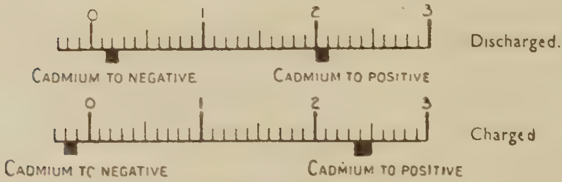


Fig. 401 —The Cadmium Battery Test.

Fig. 401 shows clearly the readings obtained for a *discharged* and a *charged* cell.

The necessary equipment consists of a voltmeter, preferably arranged for the easy carrying out of cadmium tests in addition to terminal voltage readings, and a cadmium electrode, which consists of a rod of cadmium attached to a terminal by which it is connected to one of the voltmeter terminals

Fig. 402.—The Ferranti Cadmium Battery Tester.

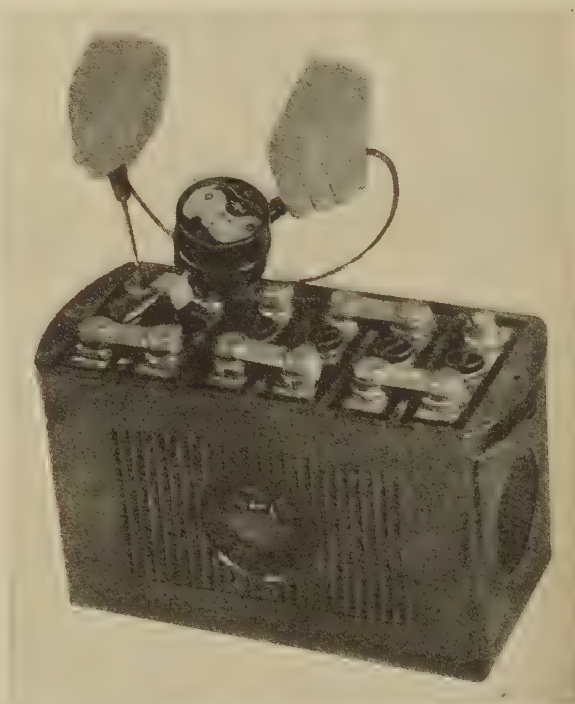


Fig. 403.—Showing how the Ferranti Voltage Tester is used.

through the usual flexible lead and spike. This cadmium rod is encased in a perforated ebonite tube, which prevents its contact with the plates when inserted in a cell. The former has, in addition, a reverse reading of ·3 volt to enable cadmium tests to be carried out without reversing the voltmeter leads. A specially sensitive instrument, such as the Ferranti Type CT2, has two ranges,

3–0–3 volts and ·3–0–·3 volt, so that very close readings may be obtained.

The cell to be tested should be charging or discharging at normal rate: it should not be an open circuit.

Attach the cadmium electrode to the spike on the negative lead, if a side zero voltmeter is used, and immerse in the cell; if possible midway between the plates. Touch the other voltmeter spike to the positive and negative terminals in succession and note readings.

A fully charged cell should show a positive reading not less than 2·35 and a discharged cell not less than 2·00 volts, whilst the negative plates should not be less than − ·10, and when discharged the polarity will be reversed, and should not be greater than + ·25 volt. This reversal of polarity is best seen when the voltmeter does not have to be reversed, as in the case with the voltmeters described above.

Fig. 402 shows the Ferranti CT2 battery testing outfit used for this method of testing, whilst Fig. 403 illustrates the method of carrying out a test; in this case a cadmium stick is inserted through the filling vent hole of the cell under test.

Care of Battery Terminals.—It is a common fault of lead-acid batteries for the acid to creep up the brass terminals, forming the characteristic green copper sulphate deposit. This salt, if allowed to form, will act as an insulator, making it difficult to get a good electrical connection between the battery and the car leads.

Each time the battery is inspected, or charged at a service station, the terminals should be well cleaned by scraping and with emery cloth, and then smeared with vaseline; copper sulphate will not form on brass or copper parts thus treated.

Cleaning Battery Terminal Posts.—The importance of maintaining the terminals in a clean condition has already been emphasised. These tapered lead terminal posts are liable to corrode if any battery acid is present. They can be cleaned either by scraping or with coarse emery cloth. A better plan, however, is to use a special tool, such as the Melco one shown in Fig. 404. One end of this tool has a hollow tapered cutter device that fits over the lead terminal post, and on rotation of the tool cleans and trues the post to the correct taper. The other end of the tool consists of a taper reamer for cleaning the inside of the brass or bronze battery cable connector. The tool is used in a clockwise direction.

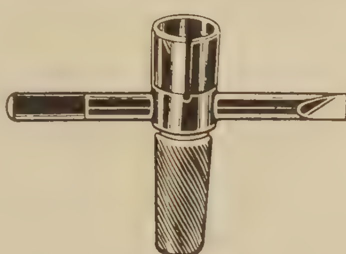


Fig. 404.—The Melco Battery Terminal and Cable Socket Cleaning Tool.

Battery Repairs

When it becomes necessary to dismantle a battery owing to some internal defect, the actual mode of stripping procedure will depend upon the type, i.e. whether of the car box battery or celluloid kind.

The car-battery type is usually provided with a moulded composition outer case (vide Fig. 392), and the top cover is sealed in place with a compound of a pitchy nature. It is necessary to soften or melt this with a wide blow-lamp flame, taking care, of course, not to burn any of the other parts. As soon as the compound is soft enough the cover may be prised off with a screw-driver, the compound having first been cleared away from the joints. The plates can then be lifted out, by the method of holding the positive and negative unit terminal posts each with a separate pair of pliers.

The plates and separators can then be examined for defects.

To separate the individual plate (external) connecting bars it is necessary to drill down a little way into the end of each bar, exactly over the centre of the plate post, as the bars are, in manufacture, forced on to these posts. The bars can then be forced off the posts; if any difficulty is experienced heat may be applied. A blow-lamp flame gently moved around the connection will be found useful in this respect.

To replace connector bars which have been removed in this way they should be tapped on to their respective posts, after first brightening or clearing the contact surfaces by scraping. A thin pointed blow-lamp flame should then be played on to the top of the plate post, and the drilled hole filled with molten lead as soon as the lead around the edge of the hole begins to melt.

Repairing Cracks in Ebonite Accumulators.—It is sometimes necessary to fill up and join cracks in ebonite accumulator cases when overhauling these. A suitable filling mixture can be made by carefully melting two parts of resin and then adding one part of finely divided gutta-percha. When properly mixed the composition is poured on a cold plate and allowed to set. To repair a crack, cut off enough of this composition, melt and apply to the crack. The sides of the ebonite should be pressed tightly together, and any excess scraped off.

The Charging of Batteries

Battery charging is an important item in garage work and, as we have before mentioned, is a profitable and constant source of revenue.

In the case of the motor owner having a source of electricity supply, arrangements can usually readily be made to deal with the charging of his car and wireless accumulators. Battery charging can thus be divided into two main classes for our present purposes, namely, (*a*) *Home Charging for the Motor Owner*, and (*b*) *Service Station or Garage Charging.*

General Charging Methods.—In connection with the commercial charging of batteries there are two principal methods employed. These are as follows:

(1) The Constant-current Method.

(2) The Constant-potential Method.

The former method consists in arranging for the charging current to be kept constant in value through the battery until the latter is fully charged.

If a number of batteries, requiring different charging rates, have to be charged it will be necessary to arrange for constant currents of different values for these. The methods of battery charging described in the following pages enable this to be done by means of a number of lamps in series and in parallel connection.

In the *constant-potential method* the electrical system is arranged to give an average voltage of about 2·5 per cell on charge. In this connection it should be remembered that the voltage of a fully charged cell of a battery is 2·6. When a partly discharged battery is charged by the constant-potential method, owing to the lower resistance of the battery when first connected there is a large current flowing through the cells, so that they are charged at a much quicker rate than that usually recommended. The constant-potential method is not universally used, although it is often employed for boosting up large electric-vehicle batteries, where time is a factor. This method is described in detail later.

Ascertaining the Polarity of Mains Leads.—As it is of the utmost importance to connect the positive side of the charging apparatus to the positive electrode of the battery to be charged, it is necessary to know which is the positive and which the negative mains lead. Once found, these leads should be labelled or otherwise marked.

If there are no indications as to which lead is positive and which negative, the leads may be identified in any of the following ways:

(1) *Voltmeter Test.*—The positive and negative terminals of voltmeters are always marked clearly, and unless the voltmeter is correctly connected with its positive terminal to the positive of the main it will not read at all. Thence if the voltmeter (which must be of a suitable type to take the full mains voltage) fails to read *the positive of the main is that connected to the negative terminal of the voltmeter.* If the voltmeter reads correctly the positive and negative leads then correspond to the markings on the voltmeter terminals.

(2) *Acid-water Test.*—If the two bared ends of the leads are placed in slightly acidulated water a few inches apart and the current switched on, the end that gives off the most bubbles is the negative one.

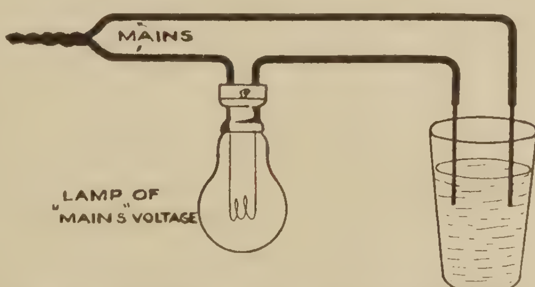


Fig. 405.—Ascertaining Polarity of the Electricity Mains.

The method in question is illustrated in Fig. 405, the mains supply being, of course, of the direct-current (D.C.) type. The bared ends of the wire are dipped into a glass of tap water which has been acidulated by the addition of half a teaspoonful of common salt. An ordinary lamp of 40 to 60 watts is placed in series with one of the leads. Bubbles of gas will appear around the negative lead when the current is switched on.

(3) *Potato Test.*—If the two copper leads are stuck in a raw potato at some distance apart, *a green deposit* forms on the wire connected to the positive supply.

(4) *Polarity Indicators.*—Special polarity indicators are now sold for the purpose of indicating the positive and negative leads of electrical supplies. The usual form of indicator is that of a glass tube having a metal cap at each end, each cap having a terminal screw for connecting to the lead to be tested.

The glass tube is almost filled with a colourless liquid, e.g. phenolphthalein, and the two terminals and caps have nickel-plated extensions arranged in the liquid. When a current is passed through the liquid the negative plate assumes a deep pink appearance and bubbles of gas collect on it. The positive plate remains unchanged in colour.

Pole-finding Paper.—This material is usually sold in the form of booklets containing strips of paper impregnated with some chemical. The paper is moistened, placed on a clean piece of wood, and touched with the bare ends of the charging leads, at least 1 in. apart. Depending upon the chemical employed, a distinctive colour will be produced on the paper, e.g. if phenolphthalein is used, a *red* spot will appear at the *negative* pole, whereas if starch iodide is used, a *blue* spot will appear at the *positive* pole.

Charging Batteries at Home.—With the advent of wireless reception the needs of the amateur in regard to battery charging have been well catered for in the shape of convenient and efficient charging devices for working off the ordinary domestic electric supply. Most of these charging devices are equally suitable for low-rate car-battery charging purposes, so that an account will be included in this section; as a rule, however, wireless battery chargers have a much lower rate of charging than those intended solely for car batteries, but are useful as trickle chargers.

The method of charging will depend upon whether the electrical supply is *Direct* or *Alternating Current*, for a battery requires direct current for charging purposes; as alternating current rapidly fluctuates from positive to negative continuously, it will be obvious that it cannot be employed. It is therefore necessary to *rectify* or convert the alternating current to direct current before it can be used for charging batteries, a valve or metal rectifier device being generally employed for this purpose.

Where direct current is available for lighting and domestic purposes it is quite a straightforward matter to charge batteries. It is only necessary to ascertain the charging-current value for the particular battery—this is usually stated on the case label—and to insert suitable resistance values in the circuit to give this charging current.

If a variable rheostat is available, this should be placed in series with the battery, and regulated until the current flowing, as shown by an ammeter also placed in series, is correct in value. Fig. 406 shows a typical charging circuit using a rheostat. In regard to the latter, the resistance coils should be kept cool when heavy currents are taken; it is usual to place these coils outside the building where the air can circulate around.

The correct value of resistance to be used will depend upon (*a*) the voltage of the supply, and (*b*) the current required.

Neglecting the small effect of the internal resistance of the battery the value of the resistance R (ohms) required to give a charging current C

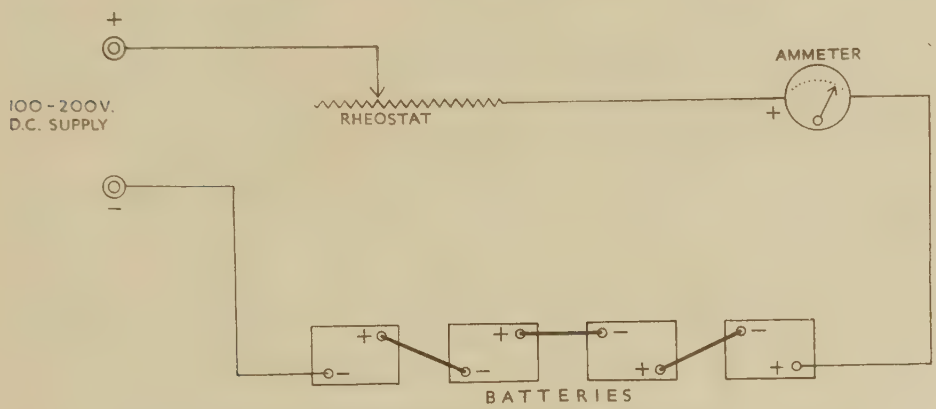


Fig. 406.—Charging Batteries in Series, using a Rheostat.

(amperes) from an electrical supply with voltage V is given by the simple relation:

$$R = \frac{V}{C}.$$

For example, if it is required to obtain a charging current of $\frac{1}{2}$ ampere from a 220-volt supply, we have for the corresponding value of the resistance:

$$R = \frac{220}{\frac{1}{2}} = 440 \text{ ohms}.$$

The following table shows a few typical resistance values for commonly occurring electrical supply voltages and charging currents:

TABLE OF SUITABLE CHARGING RESISTANCES. (In Ohms.)

Charging Current (Amperes)	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2	3	4	5
Voltage of Supply: 50	200	100	75	50	37	25	19	$12\frac{1}{2}$	10
" " 110	440	220	165	110	83	55	42	28	22
" " 220	880	440	330	220	165	110	83	55	44

Alternative Method of Finding Charging Resistances.[1]—The size of the resistance (lamps or radiators) required to limit the charging current to the required value may be obtained from the following formula:

$$W = \frac{E^2 C}{(E - 2\frac{1}{2}N)}$$

[1] Exide Battery method.

Where W = Watts marked on lamps or radiator (in *parallel* if more than one).
E = Voltage of charging mains.
C = Charging current required.
N = Number of cells in *series*.

EXAMPLE 1

Three cells, type CZ6, requiring a charging current of 6 amperes, are to be charged from 200-volt D.C. mains.

$$\text{Then } W = \frac{200 \times 200 \times 5}{200 - (2\frac{1}{2} \times 3)} = \frac{200{,}000}{192\frac{1}{2}} = \text{say } 1{,}000 \text{ watts.}$$

Therefore a radiator taking 1 kilowatt (1,000 watts) on 200-volt mains would be suitable.

EXAMPLE 2

Twenty-four cells, type BK, requiring a charging current of ·1 ampere are to be charged from a 110-volt circuit.

$$\text{Then } W = \frac{110 \times 110 \times 0{\cdot}1}{110 - (2\frac{1}{2} \times 24)} = \frac{1210}{50} = 24 \text{ watts (say 25 watts).}$$

Therefore a lamp taking 25 watts at 110 volts would be suitable.

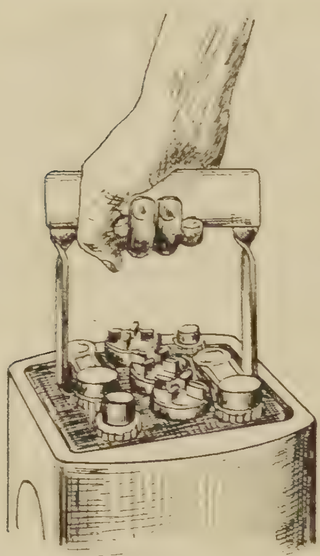


Fig. 407.—Method of Handling Car Batteries.

Handling Car Batteries.—The removal and installation of car batteries is often an awkward operation on account of their bulk and weight; moreover, the ordinary battery has no convenient projecting parts to take hold of in the hand. With the aid of the Apkoway battery handle shown in Fig. 407, however, batteries can readily be handled. The device consists of a wooden handle and two steel strips, $\frac{3}{16}$ in. $\times$ $\frac{3}{4}$ in., having lugs for insertion under the battery cell bars.

Correct Method of Connecting Batteries.—When arranging a charging plant using the ordinary two-wire D.C. electric-mains supply, the batteries should always be connected *on the negative side* of the charging resistances, as shown in Fig. 408. There is thus a much lower voltage (relatively to earth potential) on the positive terminals of the battery than if they were placed on the positive side of the charging resistances. This arrangement obviates the danger of higher voltage shocks when connecting and disconnecting the batteries.

Fig. 409 shows the " earthed main " two-wire system for battery charging. In this case, instead of running the negative of the mains back to the station cells or dynamo it is earthed.

When a three-wire mains system is used, the central wire is earthed and each of the two outer wires is positive to the central one. The batteries should therefore be on the earthed central wire side of the charging resistances (Fig. 410).

Note.—It is important to remember that this information applies only to *direct-current mains supply.*

Earthed Mains.—If one of the mains is earthed it is best to connect the battery on to it.

The mains may be tested by connecting a wire from a water pipe or other "earth" to a lamp of "mains" voltage, the other wire from the

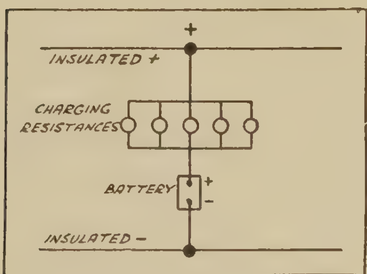


Fig. 408.—Two-wire Method (Insulated).

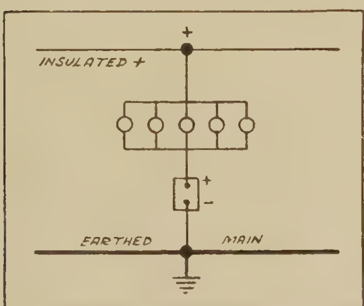


Fig. 409.—Two-wire Method (Earthed Main).

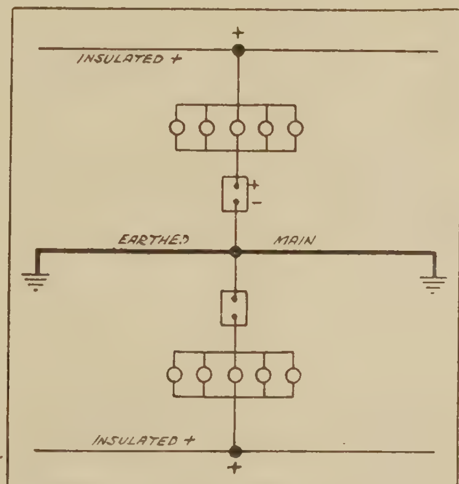


Fig. 410.—Showing Method of connecting Batteries in the Three-wire System.

lamp being connected to each of the mains in turn. (Be very careful not to short-circuit the mains when testing in this manner. Unless one has some experience in matters of this kind, it is preferable to call in an electrician.) If the lamp lights to full brilliancy on one main and not on the other, the main on which it does *not* light is the one which is earthed, and the battery should be connected to it. If the lamp does not light on either main, or it glows dimly on both mains, neither of the mains is earthed, and it is preferable in these circumstances to connect the battery to the negative main.

Using Electric Lamps as Resistances.—A more convenient method of charging batteries off direct-current supply at home is to make use of

electric lamps as resistances in order to adjust the charging current to the correct value. In this connection it is possible by arranging a number of such lamps in series, or in parallel, to obtain any charging-current value required in practice.

PARTICULARS OF ELECTRIC LAMPS FOR CHARGING RESISTANCES

Charging Current (Amperes).	*Carbon Filament Lamps.*			*Metal Filament Lamps.*		
	50 v.	110 v.	220 v.	50 v.	110 v.	220 v.
¼	—	8 c.p.	16 c.p.	15 w.[1]	25 w.	50 w.
½	8 c.p.	16 c.p.	32 c.p.	25 w.	50 w.	100 w.
1	16 c.p.	32 c.p.	60 c.p.	60 w.	100 w.	200 w.
1½	25 c.p.	40 c.p.	Three 32 c.p. in Series	90 w.	150 w.	300 w.
2	32 c.p.	60 c.p.	Two 60 c.p. in Series	120 w.	200 w.	400 w.

[1] w. denotes watts.

If it is desired to obtain any higher charging-current values than those shown in the above table, a number of lamps can be connected in *parallel* (not series).

Referring to Fig. 411, which shows four lamps connected in parallel across the mains (voltage denoted by V), if the resistances of the lamps are denoted by R_1, R_2, R_3, and R_4, then the total of combined resistance of the four lamps in parallel as shown is given by the relation:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$$

Supposing, for example, we are using four 25-watt 110-volt lamps. These have each a resistance of about 440 ohms, and the total resistance R of these four lamps in parallel will be given by:

$$\frac{1}{R} = \frac{1}{440} + \frac{1}{440} + \frac{1}{440} + \frac{1}{440} = \frac{4}{440} = \frac{1}{110},\text{ from which } R = 110 \text{ ohms.}$$

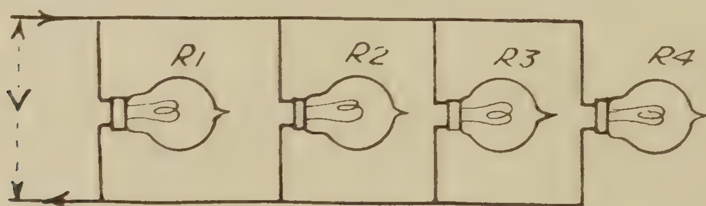


Fig. 411.—Illustrating use of Four Lamps in Parallel for Charging.

We thus obtain a simple rule for lamps in parallel, as follows:

The combined resistance of a number of similar lamps in parallel is equal to the resistance of one lamp divided by the number of lamps.

Similarly it can be shown that in the case of lamps wired up in series:

The total resistance of a number of lamps in series is equal to the sum of the separate lamp resistances.

Thus the resistance of four 110-ohm lamps in series will be four times 110, i.e. 440 ohms.

Hence, for battery-charging purposes, *to reduce the current* value connect up more lamps *in series*, whilst to increase the current connect them up *in parallel.*

Suppose it is desired to obtain a charging current of 4 amperes using

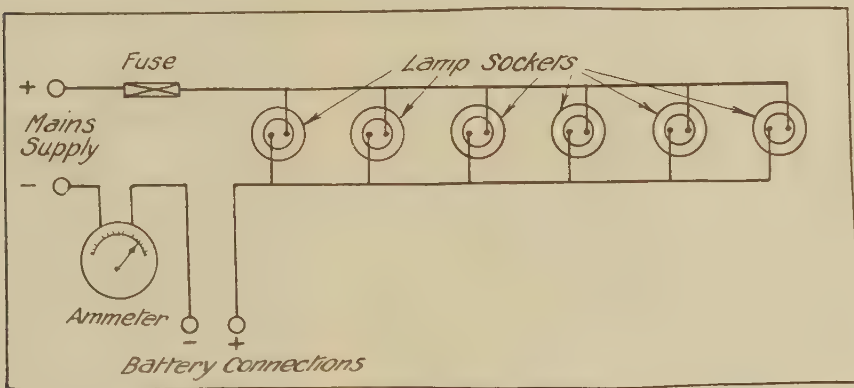


Fig. 412.—A Convenient and Simple Charging Arrangement.

only 50-watt lamps (220 volts). The resistance of each lamp, from the table given, works out at 200 ohms.

To obtain 4 amperes, on 220 volts, the resistance must be $\frac{220}{4} = 55$ ohms.

Now four 50-watt lamps, each of 200 ohms resistance, will, if connected in parallel, have a total resistance of $\frac{200}{4} = 50$ ohms. This is the best combination we can obtain with the given lamps, and it gives the correct resistance within a negligible margin.

Arranging the Lamps.—Fig. 412 illustrates diagrammatically a charging circuit using lamps in parallel. It is perhaps the most convenient method to make a charging-lamp panel consisting of a number of lamp holders wired in parallel across the main terminals, so that any number of lamps can be inserted in order to give the proper current value, as indicated by the ammeter.

It is advisable to fit, in addition, a switch and a fuse (12 to 16 amperes), as shown in Fig. 412. This arrangement with a 220-volt supply and using 32-c.p. carbon filament lamps (440 ohms resistance) will give charging currents from $\frac{1}{2}$ ampere (one lamp) up to 3 amperes (six lamps).

An Economical Home Charger.—It is possible to so arrange matters that accumulator charging may be carried out at home, at practically no

cost, by making use of the resistances of the house lamps when switched on for ordinary use.

The consumer's main switch and fuse are usually placed on the house-supply side of the electricity company's sealed service fuses and meter.

It is this main switch and fuse that lends itself to the possibility of accumulator charging at home. Briefly, the idea is simply to take a loop out between one pole of the switch and one of the fuses, and to connect in this loop circuit the accumulator to be charged. All the current that is called for by the house lamps or other fittings then passes through the accumulator on its way to them, so that no additional expense is

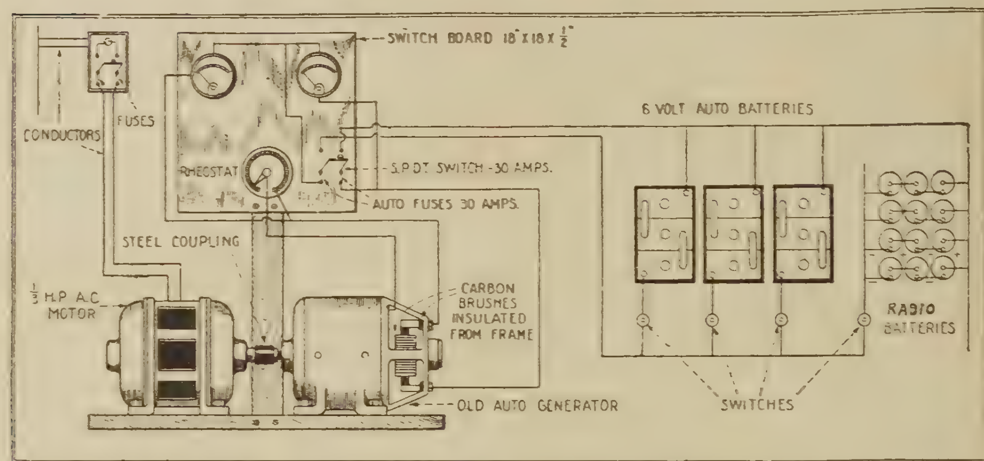


Fig. 413.—A Battery-charging Arrangement, using an old Car Generator driven by means of a $\frac{1}{3}$-h.p. A.C. Motor. A Rheostat controls the Charging Current.

entailed, and the only change in conditions is that the circuit is deprived of a few volts representing the counter electro-motive force of the accumulator.

Building an Efficient Charging Board.—The charging board illustrated in Fig. 414 is suitable for charging from D.C. mains accumulators requiring different rates of charge, e.g. L.T. car and wireless batteries and H.T. accumulators. It gives three different charging rates, metal filament lamps being used with an electric fire for the highest rates.

Diagram 1, Fig. 415, shows the ordinary charging board using a single circuit with carbon filament lamp resistances, each of which will pass about $\frac{1}{2}$ ampere. With four such lamps in circuit the current available for battery charging will thus be 2 amperes.

Suppose now that we have four batteries to charge, all at different rates; say No. 1 battery requires $\frac{1}{2}$ ampere, No. 2 battery requires 1 ampere, No. 3 battery requires $1\frac{1}{2}$ amperes, and No. 4 battery requires 2 amperes, it is quite obvious that if connected up as in Diag. 1 and all four

lamps put in circuit that batteries Nos. 1, 2, and 3 will be grossly overcharged with consequent loss of active material, while No. 4 battery will, of course, be able to stand the current, being a bigger cell.

On the other hand, if only one lamp is put in circuit, No. 1 battery will receive proper treatment, while No. 2 battery will require twice as long, No. 3 battery three times as long, and No. 4 battery four times as long to charge as No. 1 took, which means that either some customers have to wait for their battery longer than is necessary, or else someone's battery will have to suffer by being overcharged.

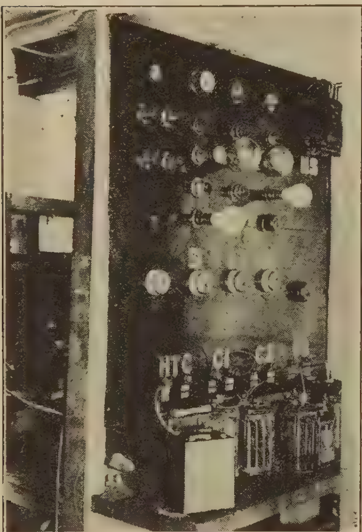


Fig. 414.—An Efficient Battery-charging Board.

If four separate charging boards are used to overcome this difficulty it means that to charge four such batteries one would have to take a total current of 5 amperes from the mains, whilst with the alterations, herewith, the same operations can be carried out using only 2 amperes total from the mains; hence the economy.

The Circuit Described

Examine the circuits shown in Diagrams 1 and 2, Fig. 415, now and it will be seen that the only difference is that a separate wire is brought from each bulb down to a separate terminal on the board, and from each terminal to a battery in the case of Diag. 2, while in Diag. 1 all lamps are in parallel and then connected to all the batteries in series; if now L1 in Diag. 2 will pass $\frac{1}{2}$ ampere, B1 will have that current flowing through it, but the current will also have to traverse B2, B3, and B4 to complete the circuit back to negative main, L2 will pass an additional $\frac{1}{2}$ ampere through batteries 2, 3, and 4, L3 will do likewise for batteries 3 and 4, while L4 will pass a further $\frac{1}{2}$ ampere through B4 only; thus B1 gets $\frac{1}{2}$ ampere, B2 gets 1 ampere, B3 gets $1\frac{1}{2}$ amperes, and B4 gets 2 amperes, the total current consumption being 2 amperes only.

Using Metal Filament Lamps.—Metal filament lamps are used in preference to carbon lamps because, apart from the lower price of metal lamps, they are to be preferred owing to the fact that the resistance of a metal lamp will fall when not run at full brilliance, whilst the resistance of a carbon lamp is at a minimum when at full brilliance; therefore, when we have a large bank of batteries to charge up, the voltage of the batteries, by opposing the voltage of the mains, will reduce the effective voltage on the lamps with consequent dimming of the lamp. If a metal filament lamp is used, the resistance falls slightly and so helps to maintain a steady "rate,"

while carbon lamps would reduce the current available to a considerable extent.

Charging from A.C. Supply Mains

It is impossible to charge a battery *direct* from an alternating current (A.C.) supply, for the current is alternately positive and negative, and each cycle produces a complete null effect. It is therefore necessary to convert

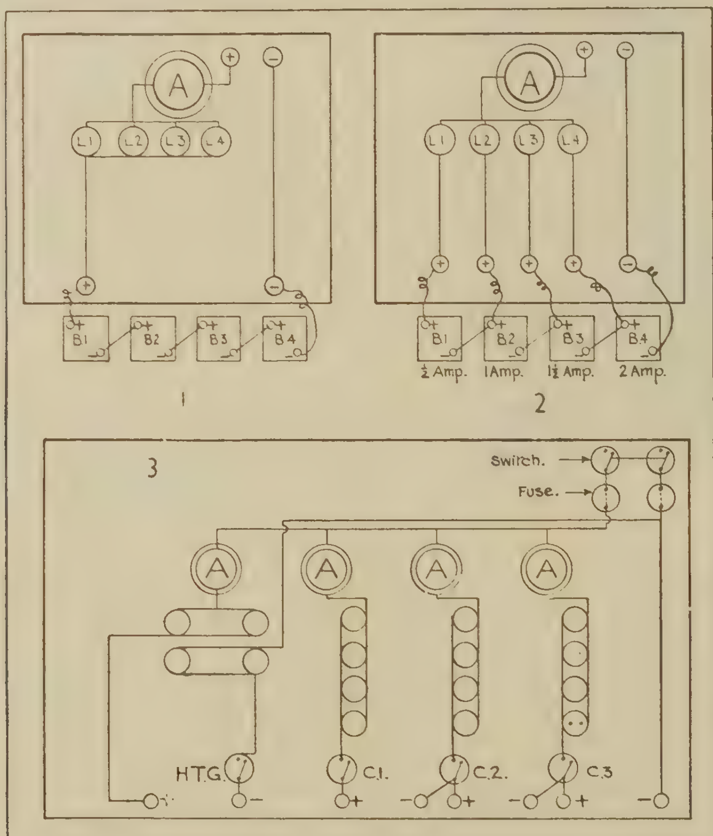


Fig. 415.—Connections of the Charging Board of Fig. 414.

the rapidly varying current into direct or constant-flow current (D.C.) before it can be used for charging purposes.

Fortunately, there are many alternative practical methods of making this conversion, and the garage engineer has the further choice of either making his own charging plant or of employing one or other of the A.C. supply chargers on the market.

The following are the principal methods of converting A.C. into D.C.:

(1) *By means of a Rotary Converter.*—In this case the A.C. is supplied to

an A.C.-type motor, which either drives directly a D.C.-type dynamo, or actually has a D.C. commutator on one side to give D.C. supply. Rotary converters of the A.C. motor and D.C. dynamo are obtainable in the form of two separate units, having their armature shafts connected together in line, mounted upon a common base plate.

(2) *By means of a Mechanical Rectifier.*—This is an electro-mechanical device which contains a vibrating spring contact, and is so arranged that the spring or springs make and break contact under the influence of current flowing in the coil, or coils, of an electro-magnet in such a way that the current always flows in the same direction in the output circuit. In effect, the mechanical vibrating device acts in synchronism with the A.C. supply (which usually varies from 25 to 50 cycles per second) and changes the contacts so as to give a direct current in the battery-connected circuit.

(3) *By means of a Mercury Vapour Rectifier.*—This method, which, however, is not used to any extent in garage battery chargers, is based on the fact that in a mercury vapour arc the current will only flow in one direction, namely from the anode to the mercury cathode, but not in a reverse direction. If A.C. is supplied to such a mercury vapour device only a direct current will flow as a result.

(4) *By means of a Valve Rectifier.*—The principle of this method is the employment of a glass valve operating on the same principle as that of the rectifying valves used in wireless sets for producing D.C. from A.C. mains supply. In these the current output is relatively small, but in the case of the rectifier valves used in battery chargers the latter will give 6 or 12 amperes, as the case may be. Moreover, the valves have useful lives extending to several thousand hours. This type is described more fully later.

(5) *By means of a Metal Rectifier.*—The metal rectifier when A.C. is applied to it allows only D.C. to flow from it. Battery chargers using these metal or dry rectifiers are of robust construction, having no valves, and will give automobile battery-charging currents of 5 to 8 amperes for a number of batteries on the same charging line. Fuller information concerning this type is given later.

Valve or Bulb Rectifiers.—This form of rectifier resembles very closely in appearance the ordinary wireless valve. It has four pins, or electrodes, and contains two metal plates, each connected to its own pin, and a low-tension filament connected across the other two pins inside the bulb. The latter is exhausted by means of a vacuum pump.

When this rectifier valve is connected up in a suitable manner to the A.C. source of supply it only allows direct current to pass.

In order to use a rectifier valve correctly it is necessary to have a transformer for giving the correct voltages to the two plates of the valve; these voltage differences are twice the value of the mains voltage. Further, the transformer must have a special low-voltage winding to give the filament-heating current.

All rectifier-valve-type battery chargers work on this principle, but,

according to the types of valves and transformers used, give different outputs to suit various requirements.

A simple type of battery charger of the valve-rectifier type can be constructed with a few components that can be purchased from wireless-accessory suppliers. All that is necessary is a transformer of the tapped-winding type, a double-anode rectifying valve, similar to that shown in Fig. 416, and a resistance valve, known as a "ballaster"; the latter tends to keep the charging current constant. The tapped transformer should be wound for an alternating-current supply of 220/250 volts, and it should have three secondary windings. One of these is to supply the filament current of 3 amps. at 2 volts for the rectifying valve; it should have a centre tapping. The second should give $1\frac{1}{2}$ amps. at 25 volts and the third one a similar current and voltage output. It has an output of 50 to 300 milliamps. at 50 volts (according to the load) and from 1 to $1\frac{1}{2}$ amps. at 8 to 12 volts.

Fig. 416.—The Cossor A.C. Type of Rectifying Valve.

The wiring arrangement of the units is illustrated diagrammatically in Fig. 417 in the case of the 220/250 volt charger.

The transformer has three secondary windings, connected up, as shown, to the rectifying valve and resistance lamp. A direct charging current of 1·5 amperes is obtained from this device. Advantages of this charger are that it is noiseless, fumeless, self-regulating, inexpensive in first cost and in use. Further, the usual type of valve is robust and inexpensive to replace.

Fig. 418 illustrates the principle of the Philips valve rectifier. In this

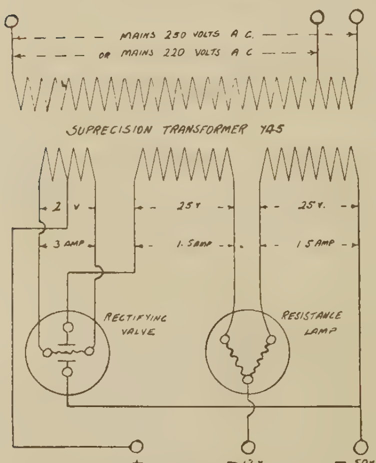


Fig. 417.—Showing Principle of Valve-rectifier Type of Battery Charger.

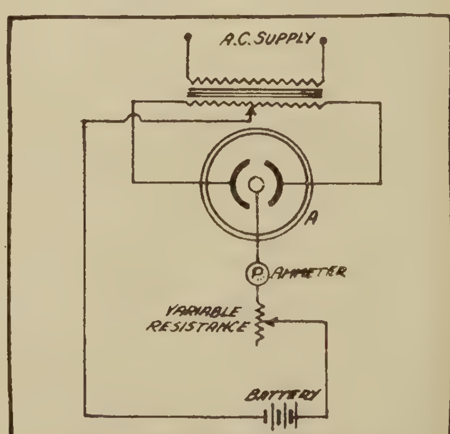


Fig. 418.—Valve-type Rectifier for A.C. Charging.

example the valve is shown at A. It belongs to the double-anode type, giving full-wave rectification. A transformer is employed, and there is an iron resistance or "barretter," known as a ballast coil, mounted in a glass bulb containing hydrogen. Its object is to stabilise the discharge, due to its marked positive temperature-resistance coefficient. In this way it can deal effectively with widely differing supply pressures and frequencies.

The Tungar rectifier, manufactured by the British Thomson-Houston Co., Ltd., Rugby, is a good example of the valve-type rectifier for battery charging. It is made in different ranges for various charging rates and purposes. Fig. 419 shows in outline a simple half-wave Tungar bulb in which the cathode consists of a filament of small-diameter tungsten wire coiled closely, and the anode, which is to be seen in the lower part of the bulb, of graphite. Fig. 420 illustrates a simple circuit diagram in the case of the Tungar rectifier; the battery on charge is indicated by the "load." It is necessary to have a transformer T for exciting the valve filament and a variable resistance R.

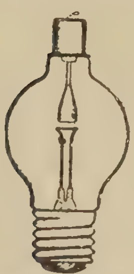


Fig. 419.—The Tungar Valve Rectifier.

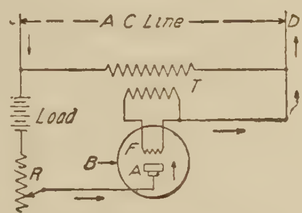


Fig. 420.—Wiring Diagram or Tungar Rectifier.

Assuming an instant when the side C of the alternating-current supply is positive, the current follows the direction of the arrows through the load resistance valve and back to the opposite side of the A.C. line. A certain amount of A.C., of course, goes through the transformer T to excite the filament.

In the actual design of valve-rectifier chargers the rheostat is omitted, and the regulation obtained entirely by means of a compensator, with which are combined the filament transformer and a reactance. When the A.C. supply reverses and the side D becomes positive, the current is prevented from flowing by the action of the valve; the current can only flow from anode to cathode, i.e. against the flow of emitted electrons, but not in the reverse direction. The Tungar battery is self-starting, it being only necessary to switch on the A.C. supply.

The advantage of this type of rectifier is that there are no moving or wearing parts. It is claimed to have a maximum charging efficiency of 75 per cent., and the pulsating current obtained is fully satisfactory for charging batteries.

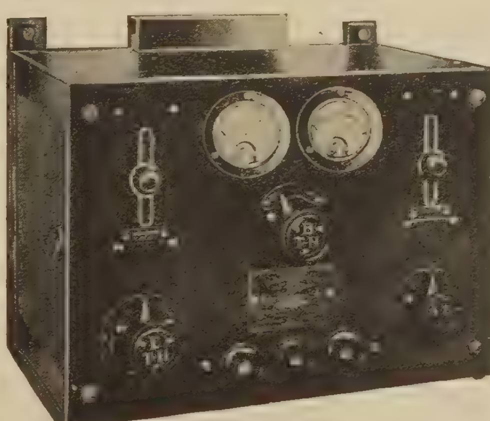


Fig. 421.—The Tungar Rectifier. Garage Model.

Dry Rectifier Chargers.—In this type of battery charger the A.C. is converted into D.C. by passing it through a series of metal discs coated with certain chemicals and pressed, or clamped, together.

Known as *dry rectifiers*, these units are compact and, relatively, of light weight. For cooling purposes the metal plates are extended around the central core, to form heat-radiating fins.

In the case of the well-known Westinghouse metal, or dry, rectifier copper discs coated with copper oxide in a special manner to render them conducting are used.

In the Elkon dry rectifier copper sulphide and magnesium discs are pressed firmly together and divided by a thin sheet-metal radiator placed at each junction in order to radiate the heat. The Westinghouse rectifier has similar copper radiators. These metal rectifiers possess the property of allowing only D.C. to pass when A.C. is supplied across them.

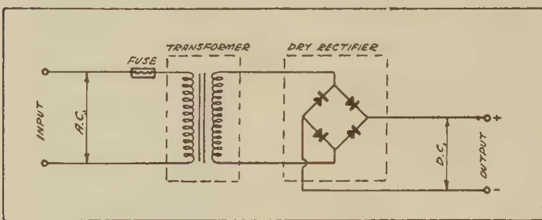


Fig. 422.—Showing Internal Circuit of Dry-rectifier Charger.

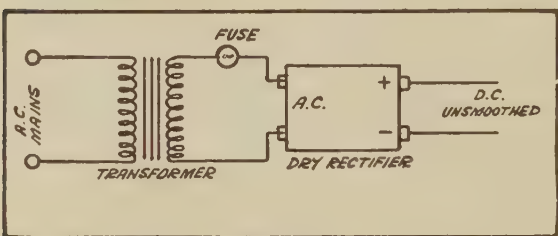


Fig. 423.—The Dry-rectifier Connections.

In recent years the dry rectifier has greatly increased in favour both for wireless purposes and for battery charging. It possesses the advantages of a much more efficient conversion of A.C. into D.C. than the valve type of rectifier. Moreover, unlike the valve type, its useful life —provided it is worked to the specified conditions—appears to be practically indefinite: thus numerous cases have come to our notice of Westinghouse rectifiers working quite satisfactorily after five or six years of constant use.

Valve rectifiers in comparison have a comparatively short life.

Further, these rectifiers are robust in construction and will stand up to hard usage and handling, whereas valve rectifiers are fragile.

Another advantage of the dry rectifier is that it does not require such an elaborate transformer as in the case of the valve type, for no filament winding is necessary. Although a transformer is unnecessary theoretically, in certain cases it is always advisable, as a safety precaution, to isolate the mains supply from the charger and batteries.

Figs. 422 and 423 show a typical circuit diagram for the Westinghouse dry rectifier; the latter consists of a number of sets of plates coupled up in the manner indicated within the dotted rectangle marked " Dry Rectifier."

A plain step-down transformer of suitable ratio for the type of rectifier

employed is connected to the A.C. mains, through a fuse, usually on the primary side and to two of the rectifier terminals on the dry-rectifier side.

Rectifier Charging Circuits

As mentioned previously, the step-down transformer used with dry or valve rectifiers brings the output voltage down to a value just above the

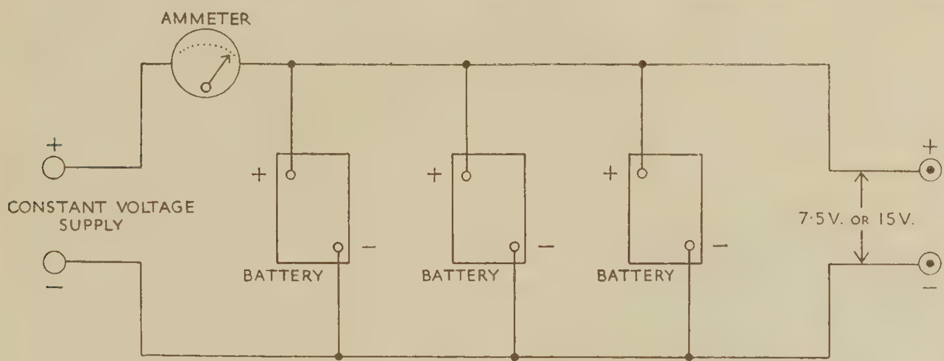


Fig. 424.—Two-wire Rectifier Supply Charging Circuit.

fully-charged voltage of the batteries, i.e. 7·5 volts for 6-volt batteries and 15·0 volts for 12-volt ones.

Fig. 424 illustrates a two-wire circuit for charging 6- or 12-volt batteries

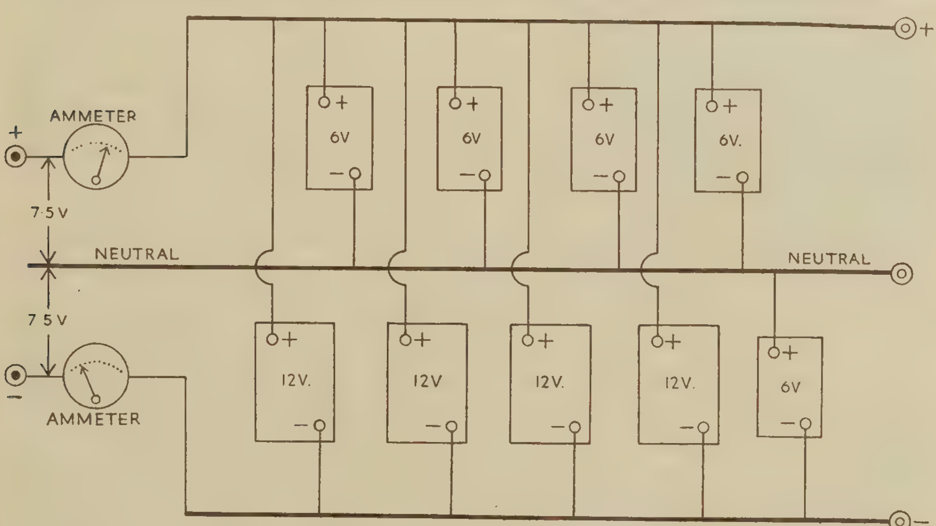


Fig. 425.—Three-wire Rectifier Supply.

in parallel from a rectified A.C. supply. In this case the positive poles of the batteries are connected to the positive supply lead.

Fig. 425 shows a three-wire circuit for charging batteries of " mixed "

voltage from two 7·5-volt rectified supply leads. It will be observed that the 6-volt batteries are connected between the positive 7·5 lead and the neutral lead, whilst the 12-volt batteries are placed across the positive and negative leads, and thus have no connection with the neutral lead.

Commercial Dry-rectifier Chargers.—Due to its relative simplicity, reliability, and robustness, this type of charger is popular for motor battery-charging purposes, and there are several makes of charger of this kind, including the Crypton, Heayberd, and Westinghouse ones. The chargers are available in various capacities ranging from the small home-garage model, capable of charging a single car battery of 6 or 12 volts at 1 or 2 amperes, to the larger model for motor-garage purposes, able to deal with 4 to 12 car batteries, as a rule, with charging rates of 5 to 8 amperes. These chargers are usually of rectangular shape with current control, switches, ammeter and main output cable connections conveniently arranged. The larger multi-circuit chargers will deal with two or three banks of batteries at different charging rates, since two or three independent circuits are provided for this purpose. Moreover, there is no need to balance the number of batteries on each circuit.

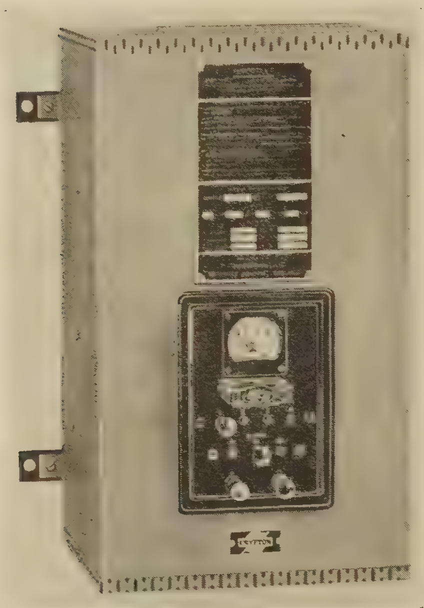


Fig. 426.—The Crypton Home-type Battery Charger.

Thus, a typical three-circuit charger will deal with 24 cells at 1 ampere, 18 cells at 5 amperes, and 12 cells at 8 amperes at the same time, corresponding to twenty-four single wireless batteries, six 6-volt batteries (or three 12-volt ones) and four 6-volt (or two 12-volt) batteries at the same time.

The Crypton units all employ selenium-metal rectifiers and transformers. The home charger (Fig. 426), which is intended for the owner-driver to maintain his car battery charged when standing for appreciable periods or under winter driving conditions, will charge a 6- or 12-volt battery or a 2-volt wireless accumulator at 1 ampere, in the case of the model A.1, and 2 amperes for the A.2, from a 220/250 A.C. supply. It incorporates a thermal overload protection device which automatically keeps the temperature of the metal rectifier within its normal rating under all conditions, thus protecting the charger in the event of accidental overload. It maintains the average current rating and the temperature of the rectifier well within its maximum without completely stopping charging.

It will be evident that these two types of chargers belong to the " trickle charger " class and will bring up a partly discharged battery to full charge

if used for a sufficient length of time; and will keep a charged battery in the fully-charged condition. The charger operates for 50 hours on one electrical unit (1,000 watt-hours).

Flexible leads for the mains and battery connections are provided and a socket connection which can be permanently wired to the battery.

A larger home charger, known as the Model A.3, intended for owners of cars in frequent use, commercial vehicles, vans, doctors' cars, etc., has a charging rate of 1 to 5 amperes at either 6 or 12 volts on 220/250 volts A.C. supply at 50 cycles. The double-wound transformer and the selenium rectifier are housed in a metal casing on which is a panel containing the 0–5-ampere ammeter and the connections for the 6- or 12-volt battery and charging rate adjustment (1, 2, 3 or 5 amperes). The latter are obtained by means of simple screw-in type plugs for the numbered terminal connections.

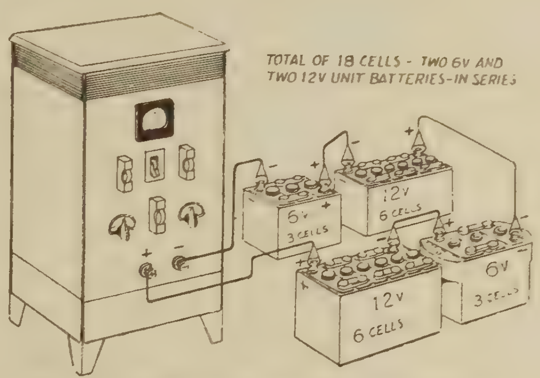


Fig. 427.—The Single Charging Circuit, with Batteries in Series.

Motor-garage Chargers

The motor-garage chargers are available with single, double, and treble independent circuits; the two latter and larger models will deal with batteries requiring two or three different charging rates.

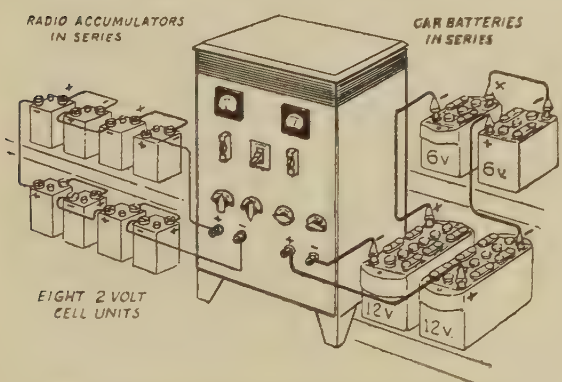


Fig. 428.—Connections for a Two-circuit Charger.

The various methods of connecting car and radio batteries in a single- and two- or three-circuit battery charger are illustrated in Figs. 427, 428, and 429.[1]

Fig. 427 shows two 6-volt and two 12-volt batteries connected in series to a single-circuit charger, using crocodile battery clips on the connecting leads. It will be observed that the negative of the first (6-volt) battery is connected to the negative terminal of the charger and the

[1] Courtesy of Crypton Equipment Co., Ltd., Bridgwater.

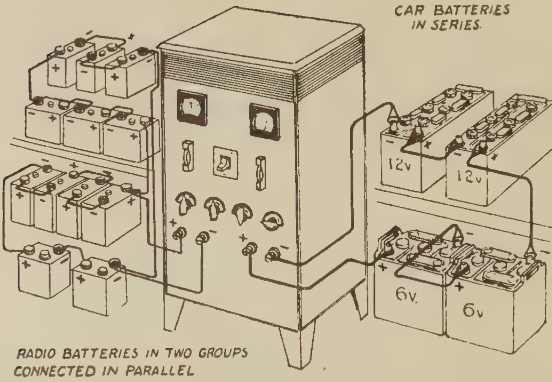


Fig. 429.—An Alternative Charging Arrangement.

positive of the last (12-volt) battery to the positive of the charger. The polarities of the other battery connections are clearly shown.

Fig. 428 illustrates the one possible arrangement for charging radio accumulators, 6-volt and 12-volt car batteries on a two-circuit charger. The polarities of the various connections are here plainly indicated.

Fig. 429 shows the method of connecting car batteries in series on the high-output circuit and radio batteries in series-parallel on the low-output circuit.

The Rapid-boost Battery Charger

For garage purposes the Crypton *portable rapid battery charger* illustrated in Fig. 430 possesses several advantageous features. It incorporates a new method of charging car and commercial-vehicle starter batteries in an average time of one hour, without temporary or permanent injury to the battery. Moreover, it can be used for testing batteries in vehicles and ascertaining whether these are in good condition or require servicing or replacement. It will charge up to ten batteries on the bench and is fully automatic in action. It is equally suitable for 6- or 12-volt batteries.

Fig. 430.—The Crypton Portable Rapid Battery Charger.

The design of the charger is such that for a 90-ampere-hour battery in good condition the charging current for the discharged battery commences at 80 to 90 amperes and decreases to about 65 to 70 amperes at the end of one hour. During this period the acid density increases from about 1·180 1·300 and its temperature from 60° to 105° F.

A marked advantage of this charger is that it can be wheeled about the garage or works and connected up to batteries on vehicles so as to charge them whilst other servicing or repair work is proceeding. As shown in Fig. 431, a car is on the hoist for inspection and greasing purposes,

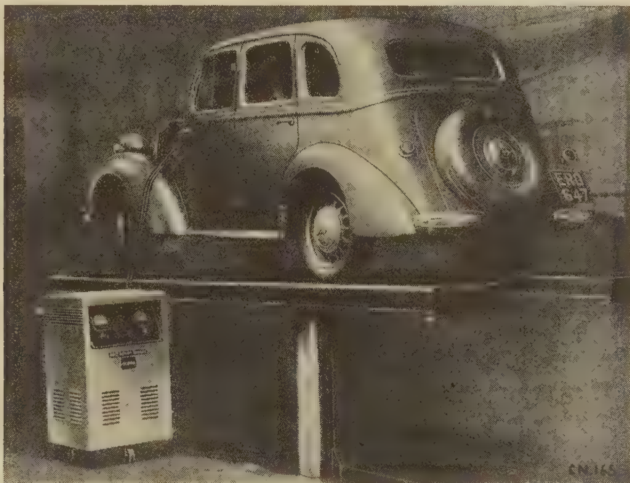


Fig. 431.—Rapid Battery Charger shown in use on Car Battery.

whilst at the same time its battery is charged up fully. It is also useful where cars will not readily " crank over " in cold weather owing to partly discharged batteries.

The same unit is fitted with apparatus for testing batteries under correct

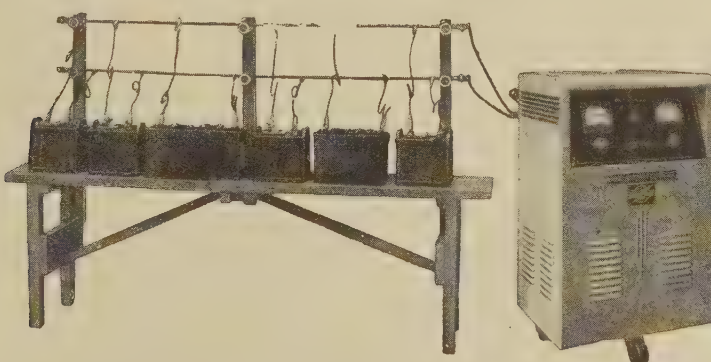


Fig. 432.—The Crypton Rapid Battery Charger as used for garage charging purposes.

heavy discharge conditions to ascertain whether they are suitable for fast charging or require slower charging rates, replacement or service, by means of a variable high-rate discharge resistance and moving-coil voltmeter and

an ammeter. It measures the voltage of each cell under correct discharge load conditions. The meter has coloured zones to show at once whether the battery can be rapidly charged or otherwise.

For shop charging the output is 50 amps. 15 volts (continuous) and five 12-volt or ten 6-volt batteries in parallel can be charged at 10 amperes. Or eight 12-volt or sixteen 6-volt batteries can be charged at 6 volts. Fig. 432 shows the portable charger wired up to bus-bars with a number of batteries connected to the bars, in parallel.

The Constant-potential Charging Method.—In this method the batteries are connected in parallel to a low-voltage motor-generator set supplying current at $7\frac{1}{2}$ or 15 volts on the two- or three-wire systems. The number of batteries that can be charged is limited only by the rated output of the generator.

Fig. 433 illustrates the three-wire system. It will be seen that in the latter case both 6-volt and 12-volt batteries can be charged simultaneously by using the inner and outer bus-bars, as shown.

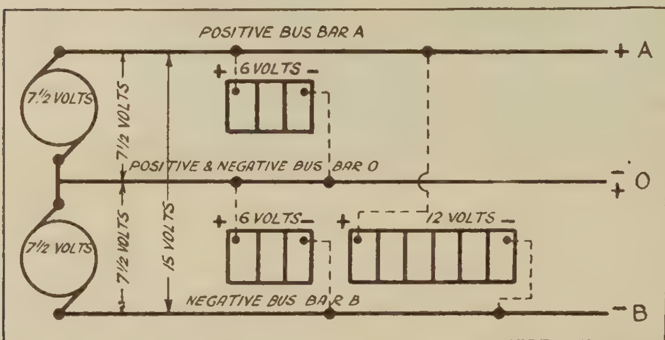


Fig. 433.—Showing Principle of the Constant-potential Battery-charging Method.

The charging rate is determined by the voltage of the battery. Thus if the battery is "low" there will be a relatively large difference between the voltage of the generator and that of the battery, so that the *charging current will be a high one.*

As the battery charges up, the voltage difference diminishes and the charging current becomes progressively less, thus tapering off as the battery approaches the fully-charged condition.

The generator is provided with either manual (rheostat) or automatic means of regulating the voltage supply to the charger bus-bars.

Referring again to Fig. 433, this shows the arrangement of the Newton constant-potential charging set. It consists of three bus-bars, the outer ones, A and B, being maintained at 15 volts potential difference, and the inner one at $7\frac{1}{2}$ volts potential difference to each of these.

The batteries to be connected are clipped to these bus-bars in 6- or 12-volt units. The 6-volt units, which can either be 6-volt batteries or, say, three 2-volt cells, are connected between either outer bus-bar and the neutral, that is, to A and O or O and B, and 12-volt batteries or 12-volt battery units connected across the outer bus-bars, that is, A and B.

Exactly what happens can be seen by taking, say, a 6-volt battery and

connecting it across bus-bars A and O. Bus-bar A is positive and O is negative. The voltage between the bus-bars is higher than the voltage of the battery into which the current will flow. The voltage across these two bus-bars is $7\frac{1}{2}$ volts. The voltage of the 6-volt battery when connected can be taken as, say, 5·5 volts. When the battery is first connected the current which will flow is equal to the difference between 7·5 and 5·5, i.e. 2 volts, and will, at this point, be heavier. As the battery becomes charged its voltage will gradually increase, but as the bus-bar voltage of $7\frac{1}{2}$ volts is maintained constant, the difference between the two voltages will progressively reduce and as the current is proportional to this difference, the current will also progressively reduce and a taper effect will be experienced. When the battery is fully charged the voltage will be 7·5 volts, which is

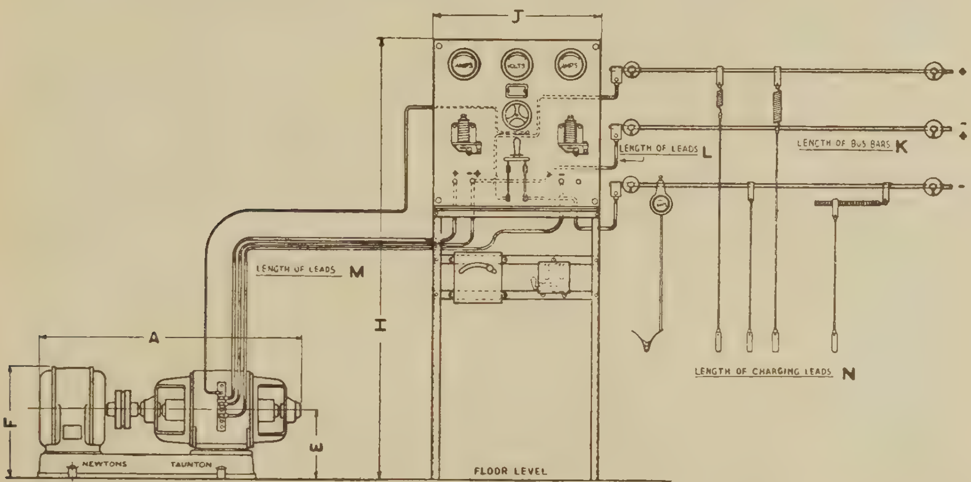


Fig. 434.—General Layout of Constant-potential Battery-charging Plant. A.C. Mains Type. [The letters refer to the principal dimensions for specification purposes.]

equal to the bus-bar voltage and, consequently, no charging current will flow. It is important to note that it is necessary with the constant-potential system to choose the most suitable bus-bar voltage and also provide means for the prevention of too heavy a current in the case of badly sulphated batteries, also to prevent overheating in similar cases.

The Newton constant-potential charger will deal with all sizes of batteries simultaneously, and any battery can be specially treated where required without interfering with the others.

The time required for battery charging with this system is about eight hours.

The equipment is provided with full protection in the matter of *automatic cut-outs* to the switchboard; *these disconnect the batteries from the windings of the dynamos* in the event of the plant being shut down or through failure of the electrical supply.

Fig. 434 illustrates the general layout of the Newton battery-charging motor generator set.

The *motors* of these generators are built for operation on D.C., three-phase alternating or single-phase alternating current of any frequency or voltage.

The *generator* is of the open protected shunt-wound type designed for battery charging and is mounted with its driving motor on a heavy cast-iron base plate. The sets run at a speed of about 1,400 r.p.m.

The *switchboard* equipment varies with the number of charging circuits required, but the standard equipment includes a main ammeter and voltmeter, double-pole main switch, single-pole main fuses, and shunt field regulator.

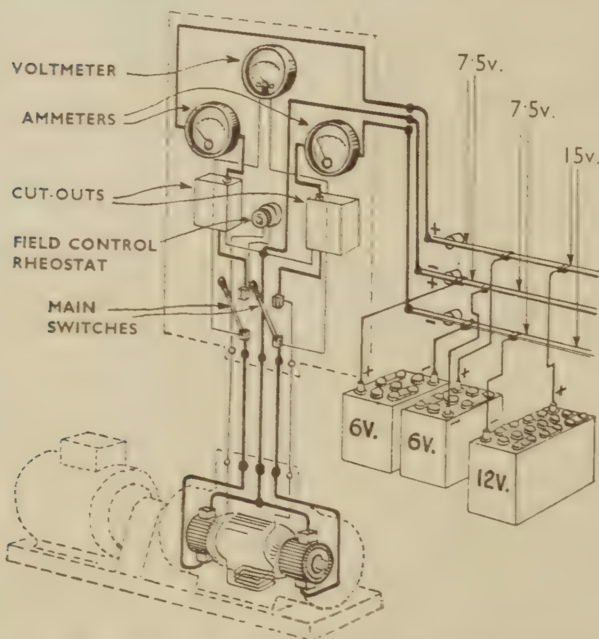


Fig. 435.—The Crypton Constant-potential Three-wire Battery-charging Equipment.

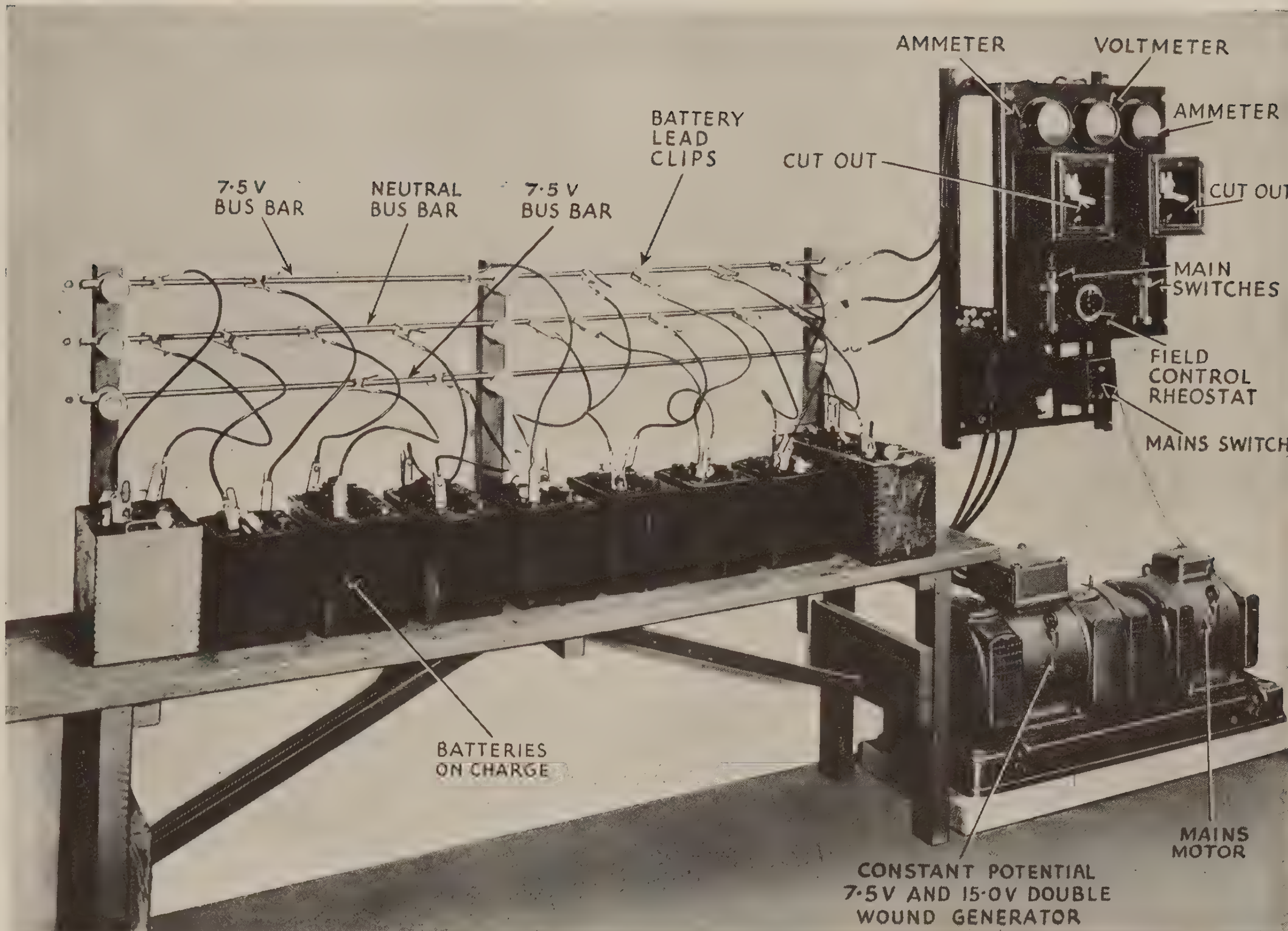
There is a wide range of available outputs to suit practically all requirements. Generally speaking, multiple-circuit equipments are preferable to single-circuit ones, unless only one type of battery is to be charged.

The general layout of the Crypton constant-potential three-wire battery charger is shown in Fig. 435. This provides independent charging of 6-volt and 12-volt batteries with a safe tapering charge, and will give an initial charging rate up to 40 amperes, which quickly falls as charging proceeds. In 5 hours the battery is nearly charged, and at the end of 8 hours it is fully charged. Thus it is possible with batteries in good condition to charge them in a day.

New batteries can be charged at their (lower) initial rates by using the special leads provided.

This type of charger is available in the 100-, 200- and 300-ampere models, i.e. they will give total charging currents for all the batteries connected which add up to the ampere ratings given. Thus a 100-ampere unit will charge 10 batteries in 8 hours or 20 in 16 hours.

A 300-ampere unit will charge 30 batteries in 8 hours or 60 in 16 hours.



THE CRYPTON CONSTANT-POTENTIAL THREE-WIRE BATTERY-CHARGING EQUIPMENT SHOWN IN OPERATION.

General Notes on Battery Chargers

When using a battery charger for groups of batteries the following notes should be useful to the operator:

(1) Select the charging rate of each separate circuit of the charger to be the same as that of the smallest-capacity in the circuit. It is not advisable to give more than about 25 per cent. above the recommended small battery rate.

(2) As the batteries become charged, the current will begin to fall, and when fully charged the current may drop to about two-thirds of its initial value, i.e. if initially 6 amperes it will fall to 4 amperes.

(3) The batteries are considered fully charged when their acid densities are 1·28 to 1·30 (according to make) for car batteries and 1·250 for radio ones. Moreover, the cells should gas freely. Charging should continue for 1 to 3 hours after attaining the correct acid density.

(4) Arrange for good ventilation of the battery-charging room, as the hydrogen and oxygen as well as acid fumes should be got rid of. Further, do not use any naked lights near the batteries, as hydrogen and oxygen form an explosive or combustible mixture.

(5) Should the ammeter show "no charge," examine the fuse or fuses and see that the charging switches are "On." If a fuse is blown, check up the cause—which will probably be a short-circuit somewhere in the fuse-protected circuit.

Another cause of a "no charge" reading is a dislodged or faulty connection to one of the batteries.

(6) Always switch off the battery charger from the mains when making any connections for charging, and before taking off charged batteries.

(7) Adjust the charging rate gradually. In some chargers there is a "Coarse" control for the nearest value below the correct rate and a "Fine" adjustment control to bring it to the correct rate.

(8) Keep all terminals clean and free from acid or grease when in use.

Charging a Small from a Large Battery

It is not generally known that it is possible to charge a small battery by utilising some of the energy stored up in a larger battery. In order to do this it is necessary to provide some form of resistance in order to limit the current discharge of the larger battery. If the latter were connected direct, there is the risk of ruining the smaller battery's plates due to the heavy discharge. The best method is to use one or more carbon filament lamps in series. If an ammeter is available this should also be connected in series and the resistance regulated by using a suitable wattage of lamp to give the correct charging rate recommended by the manufacturers of the battery.

Safety Precautions in Charging Stations

In view of the fact that there have been several cases of serious fires occurring in charging stations, it is necessary to take certain precautions. In this respect, the National Fire Brigades Association, 6 Waterloo Place, London, S.W.1, have issued a Warning Notice, printed in red, and suitable for posting up. This can be obtained on application.

The following are the important precautions which should be observed:

(1) Stand accumulators whilst being charged on thick pieces of glass, porcelain, glazed earthenware, or slate spaced on sheet lead in such a way as to allow any acid to flow on the lead between the pieces of glass, etc. The lead should be so arranged that it can be readily washed down, and it must be efficiently earthed. If a small amount of sawdust is spread on the lead to absorb any acid it should be removed and put outside as soon as it becomes appreciably damp.

(2) Do not allow accumulators to touch any wood or other absorbent material during charging. There should be a clear space of at least 6 ft. above accumulators if the material above is combustible.

(3) Allow clear space of at least 1 in. all round each accumulator if two or more are being charged in series.

(4) Where electric current is from a three-wire system (i.e. two live wires and one earthed wire) only connect charging plant to one live wire and the *earthed* wire.

(5) If supply is taken from mains of which one wire is earthed, *couple accumulators direct to the earthed wire with no lamps or other resistances intervening.* Any resistances should be introduced between the accumulators and the wire which is not earthed.

(6) If lamps are used as a resistance the holders should be securely fitted to a stout board of hard wood covered with asbestos. Only carbon filament lamps should be used.

(7) Insert fuse (not exceeding 10 amperes) between lamps or other resistances and main switch. The lamps, etc., should be securely fitted. Each set of accumulators being charged in series should have a separate fuse in circuit.

(8) All leads or wires should be efficiently connected by means of lugs soldered or sweated to the stranded cables, which should be well insulated down to the point of contact on the accumulator, and as far as possible the wiring should be of a permanent character. All terminals should be tightly screwed down to prevent sparking. All leads or wires should be capable of carrying a greater load than the fuse.

(9) Do not smoke or use naked lights within 2 yds. of batteries, as celluloid is highly inflammable, and an inflammable and explosive gas—sulphuretted hydrogen—is evolved during the process of charging. In addition, if the accumulators are overcharged, the water is resolved into its original gases and an explosive mixture may be formed.

(10) Where a number of celluloid-cased accumulators are being

charged provision should be made for the charging to be done in an outbuilding. Separate compartments of fire-resisting materials should be provided so that not more than twelve accumulators are close together. The sides of the compartments should be at least 3 in. higher than the cells.

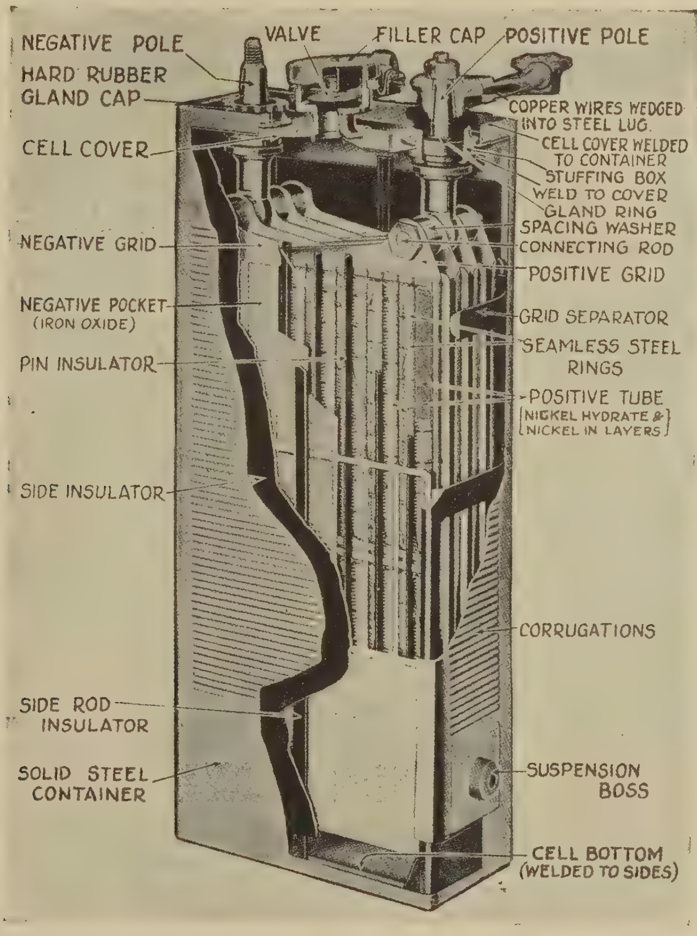


Fig. 436.—The Edison Nickel-iron Cell, showing its Construction.

(11) Current should on no account be left on all night unless someone is in attendance.

(12) Water should not be thrown on any fire until the electric current has been switched off.

These precautions can be carried out with but little trouble and at small expense.

Buckets of water should always be available, and also buckets or bins of dry sand with scoops.

Stout blankets are useful for smothering incipient fires.

Nickel-iron Accumulators

Although the majority of batteries dealt with by garages and charging stations comprise the lead-acid type, occasionally the nickel-iron battery as made for commercial vehicles will require attention. In view of the important differences between the two types, it becomes necessary to point out the correct manner in which to treat the nickel-iron cell sent for charging or overhaul.

It is necessary to understand the construction of this type before filling or charging it.

The nickel-iron cell (Fig. 436) is represented in this country principally by the Nife, Edison, and Ionic accumulators. It differs entirely from the lead-acid type in that the pockets of the negative plates contain mainly pyrophoric iron of an extremely delicate manufacture, and the positive hydroxide of nickel mixed with graphite. The electrolyte is a chemically pure, alkaline solution, chiefly composed of potash. The chemical actions during the charging of the cell can be briefly outlined by stating that the iron oxide and nickel oxide (NiO), in the presence of the alkaline electrolyte, are converted into pure iron and a different nickel oxide (Ni_2O_3). During the discharge a reverse chemical action occurs. In reality the reactions are more complicated. The metallic iron is transformed during the discharge not only into ferrous oxide but also into ferric oxide. The hydroxide of nickel, on the other hand, is partially oxidised during the charge into a peroxide of the formula Ni(OH)t. The foregoing process shows that the chemical phenomena amount simply to a transference of the oxygen from the iron to the nickel for the charge, and from the nickel to the iron for the discharge. The function of the electrolyte is solely to facilitate this reaction in which it has no part. This essentially differentiates the alkaline cell from the lead accumulator, and makes it a much less delicate apparatus.

The *voltage* of the nickel-iron cell is about 1·5 during the charging process, falling off to 1·3 after the first hour of normal discharge, and thence progressively to 1·1, after which the voltage drops rapidly. Fig. 437 shows the charge and discharge curves of the Edison battery when charging and discharging at *constant current*. The average working voltage is 1·2 volts at the normal five-hour rate of discharge; at lower rates this value is nearly 1·3 volts.

Density of Electrolyte.—Unlike the lead-acid type, the alkaline solution will work between a relatively wide range of densities, namely from 16 to 30 per cent. concentration, without affecting the output. It is only necessary to replace the alkaline solution after every 350 discharges. *When a nickel-iron cell is charged it should be "topped" with distilled water only.*

Charging Edison-type Nickel-iron Cells.—It is possible to charge this type of cell very rapidly. In the case of Ionic cells, charging can be carried out at constant terminal voltage (1·95) in no less than one hour. For a fifty-hour charge the terminal voltage is about 1·6; for a ten-hour charge rate, 1·72.

It is unnecessary to take any special precautions when storing nickel-iron cells for long periods; these cells may be left unused for periods up to

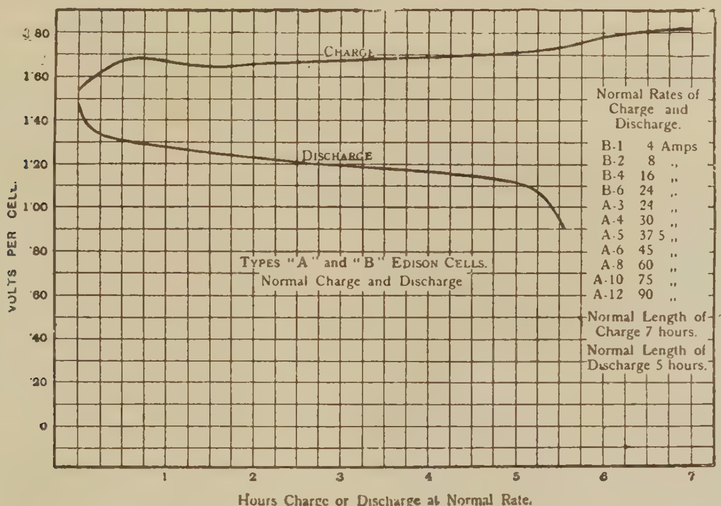


Fig. 437.—Performance Curves of Edison Cell.

ten years without detrimental effect. The plates deteriorate only through work; that is to say, in terms of the number of discharges to which they are subjected.

It is very unusual to find any solid deposits in the base of a nickel-iron cell.

Further, this type of cell will withstand much bad usage, such as over-charging, short-circuiting, and excessively rapid discharge, without any appreciable effects.

It is more expensive in the first place than the lead-acid type, but reckoned in terms of years of useful life it is greatly superior; moreover, it costs less to maintain, and is unaffected by vibration, long periods of in-activity, or excessive discharges.

As regards *weight*, the nickel-iron cell gives from 7 to 12 ampere-hours per pound of assembled battery. It will give an output of 1 h.p. hour per 50 to 60 lb. weight; another way of expressing the same statement is that it gives about 8·5 watt-hours per pound in the smaller sizes, up to 15 in the larger ones.

Advantages of the Alkaline Battery.—The nickel-iron, or alkaline, battery has several important advantages over the lead-acid one. These may conveniently be summarised, as follows:

(1) It is much lighter for a given capacity.
(2) It is much stronger, being of all-steel construction as a rule.
(3) It is not damaged by overcharging or rapid discharge.
(4) It evolves no corrosive gases, although special care is needed when charging this type of battery not to bring a naked light in its vicinity, since the gases (hydrogen and oxygen) are explosive, as in the case of the lead-acid battery.
(5) It has a longer life than the lead-acid battery.
(6) Is unaffected by vibration.
(7) Is especially efficient for starting purposes, in particular for automobile oil engines.
(8) Has a negligible self-discharge so that, unlike the lead-acid battery, it will stand for long periods without loss of power (or charge).

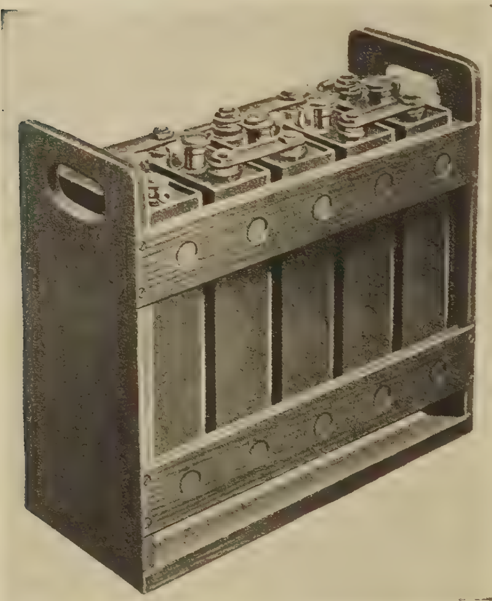


Fig. 438.—A Battery of Five Nickel-iron Cells in Crate.

The C.A.V.-Nife Battery.—This alkaline battery is of the nickel-cadmium type and is employed for commercial-vehicle batteries; in particular, those of oil-engine vehicles. They are available in two principal classes, namely for lighting and for starting.

The constructional features of this battery are illustrated in Fig. 439, from which it will be seen that the outer container is of rust-proof steel with welded bottom joints. The plates are built up by enclosing the electrochemically active materials inside a finely perforated steel envelope; this effectively prevents loss of active material under severe jolting conditions. The plates are separated by small-diameter ebonite rods. The electrolyte has a preservative effect on the steel surfaces with which it is in contact.

These batteries are made in capacities ranging from 35 to 240 ampere hours. The 12-volt battery is made up from 9 cells connected in series; the 24-volt battery from 18 cells in series. Special wooden crates or boxes are required for making up batteries of various voltages. The density of the electrolyte in the new C.A.V.-Nife cell is 1·170 and, in this type, it is important not to allow the density to fall below 1·160.

The charging current for this battery is 9 amperes for the 35-ampere-hour battery up to 58 amperes for the 240-ampere-hour battery. For the charging rates prvio-usly mentioned the time required is 10 to 12 hours for the new battery (first charge) and 6 to 7 hours for subsequent rechargings.

The voltage per cell is 1·4, but during charging the voltage should be increased for the first 4 hours, so that when fully charged it will fall to 1·4 volts.

As the density of the electrolyte is especially important for these cells it is necessary to employ a pipette hydrometer having a range of about 1·15 to

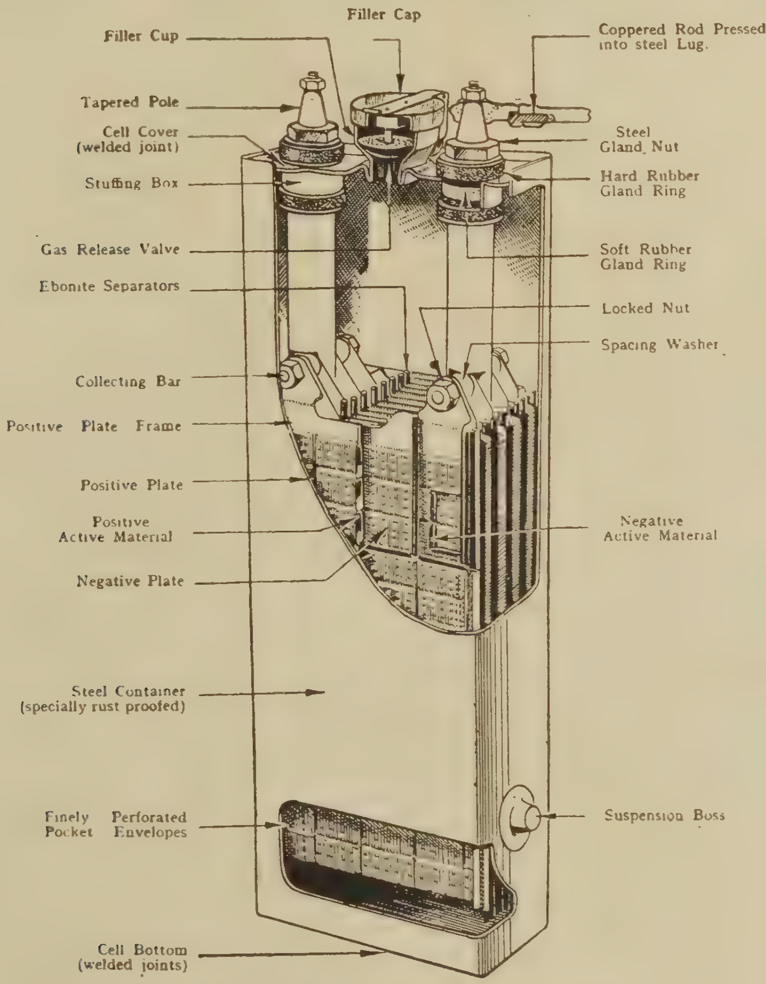


Fig. 439.—Sectional View of C.A.V.-Nife Cell, showing its Construction.

1·18, such as that illustrated in Fig. 440. This has two detachable nozzles (*a*) to give the correct height of liquid over the plates (this is an important factor) and (*b*) for use with the hydrometer inside the pipette for taking specific gravity (density) readings. The first nozzle is used by inserting it until it touches the top of the plates, when it is squeezed and released, thus drawing up surplus liquid if the cell is too full.

The temperature of cell-to-cell connections should be tested during charging, and any that feel hot should be examined for slackness. If this is not the cause of the trouble, they should be disconnected and the surfaces examined and cleaned.

The usual indications by which the state of charge (or discharge) of a lead-acid battery is known do *not* apply to nickel-cadmium cells and *gassing is no indication whatever that a battery is fully charged.*

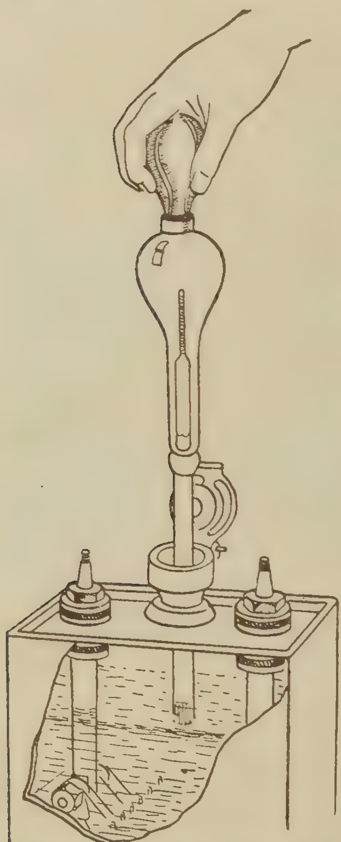


Fig. 440.—Method of Testing Density of Electrolyte.

Charging.—The C.A.V. vehicle-type dynamo is normally able to keep the battery fully charged and in good condition. There may, however, be special cases where the daylight running time is short or the night standing periods unduly long, and under these circumstances the battery may occasionally run down. If there is a tendency for this to occur, the battery should be removed periodically from the vehicle and given a six-hour charge at normal rate, or a twelve-hour charge if completely exhausted. It should be remembered that, unlike the lead-acid cell, the *C.A.V.-Nife battery benefits by continued overcharging*, but is liable to damage if it is regularly and completely exhausted.

Discharging.—It is recommended that, as far as possible, the work done by a battery should be at the normal rate of discharge. The exigencies of vehicle lighting service, however often require discharges at rates widely removed from the normal, and in this respect the C.A.V.-Nife cells display marked ability to meet the demands made upon them.

Over-Discharging.—Repeated over-discharging is injurious to the cells. A battery is normally considered to be discharged when the voltage is down to 1·1 volts per cell at *normal discharge rate*, and as a general rule batteries should not be discharged below this point.

The tops of the cells, including the terminals, should be given a good coating of mineral oil jelly or vaseline.

Topping-Up.—The cells should be examined for electrolyte level and if found too low (under normal service conditions, but not by spilling) should be topped up with distilled water. The electrolyte should be about ¼ in. above the top of the plates.

CHAPTER 12

CAR RADIO

A DOMESTIC wireless set and a car radio receiver are basically the same, but they work under very different conditions. The first can have a long aerial and unlimited power from the mains. It can work in comparatively quiet

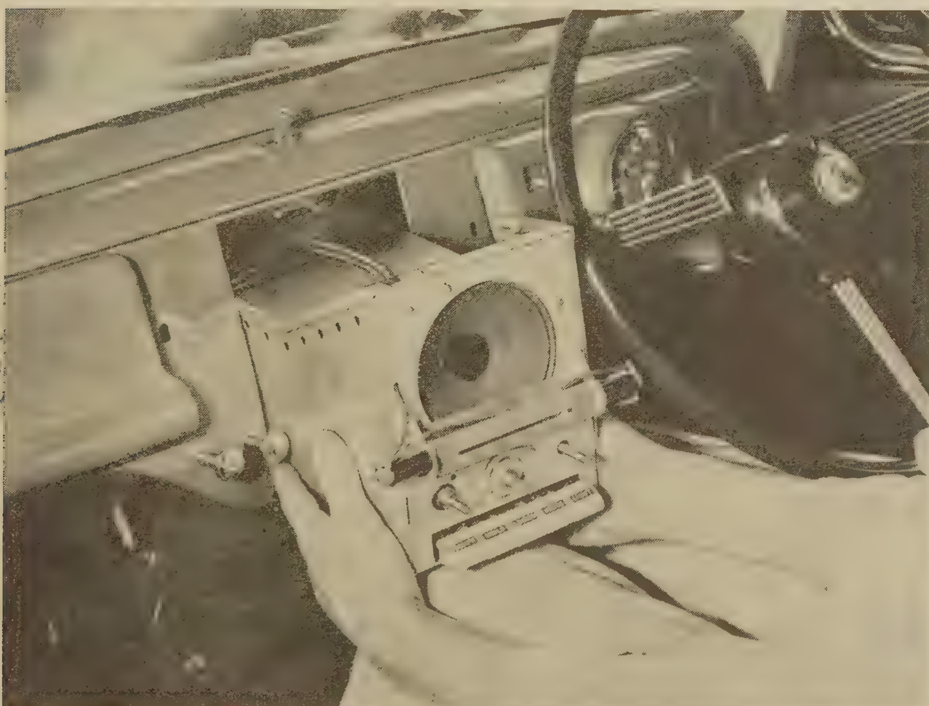


Fig. 441.—Receiver in process of being fitted to a Vauxhall Car.

surroundings, and size is not generally important. The car radio can have only a very short aerial and a minimum of driving power. It must work in conditions of noise and vibration; be small, compact, and very simple to tune. Modern designs meet all these requirements. A typical set needs

a space of 7 in. cube and a driving power of 30 watts or so. It will give a good output of sound from any of the four to six broadcast stations to which it can be tuned.

The arrangement of car radio sets usually follows one of two general patterns. The first is self-contained. Set, speaker, and power supply are all housed in a single case arranged for fixing to the dashboard. The sound output of this type is necessarily limited because of the small physical size of the loudspeaker, but the radio performance is quite good. An installation of this type is adequate for the needs of a driver and single passenger. The second pattern makes use of the unit system. In this, set and control panel are usually mounted on the dash. The power supply is a separate

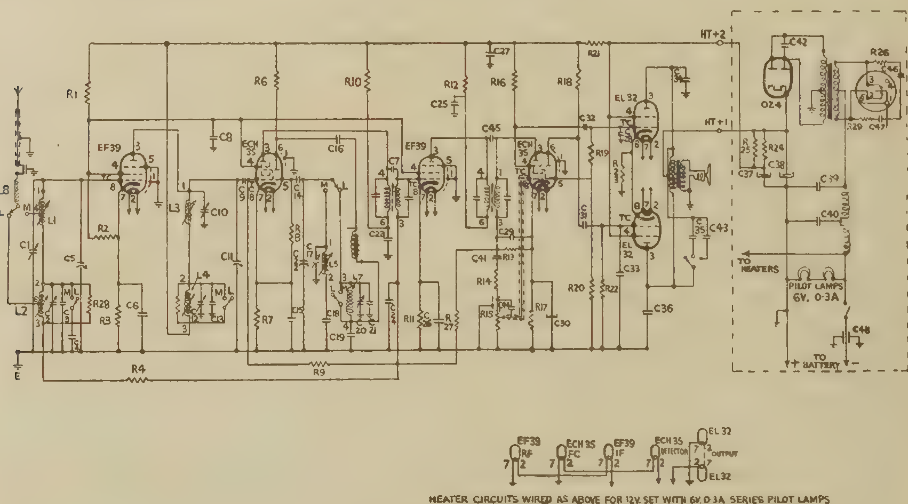


Fig. 442.—Circuit Diagram of the Receiver shown in Fig. 441.

unit, as is the loudspeaker, and these can be fixed where convenient. This arrangement allows a good many alternatives. Extra speakers can be fitted in the vehicle, the set can be controlled from two or more places and may itself be stowed in alternative positions in the car.

Fig. 441 illustrates a set of the first kind in process of fitting to a Vauxhall car. The circuit (Fig. 442) is arranged to receive both medium and long waves and there is an aerial filter for both ranges. The first valve is a H.F. amplifier, and is followed by a triode-hexode mixer and a single I.F. stage. The next valve is also a triode-hexode but is used as a signal detector and A.V.C. diode as well as a phase splitter for feeding the push-pull output stage. Tuning is by push-button or manual control.

An example of a larger and more elaborate equipment is shown in Figs. 443 and 444. This is an Ekco product and, as Fig. 443 shows, it is made up of three units: the set, the control box, and the power supply. Fig. 444 is a view of the set and the power supply with the covers removed.

The receiver is an eight-valve superhet working on long, medium, and seven short-wave ranges. Tuning is either manual or by a switch giving instantaneous station selection. Three of the short-wave ranges have band-spread tuning. The effect of this is to reduce the normal change in frequency for a given rotation of the tuning control. Stations therefore appear to be spread out on the dial and are accordingly much easier to select. The power output of the set is sufficient to drive four loudspeakers. This makes it particularly suitable for use in large cars or coaches. The short-wave ranges cover most overseas requirements.

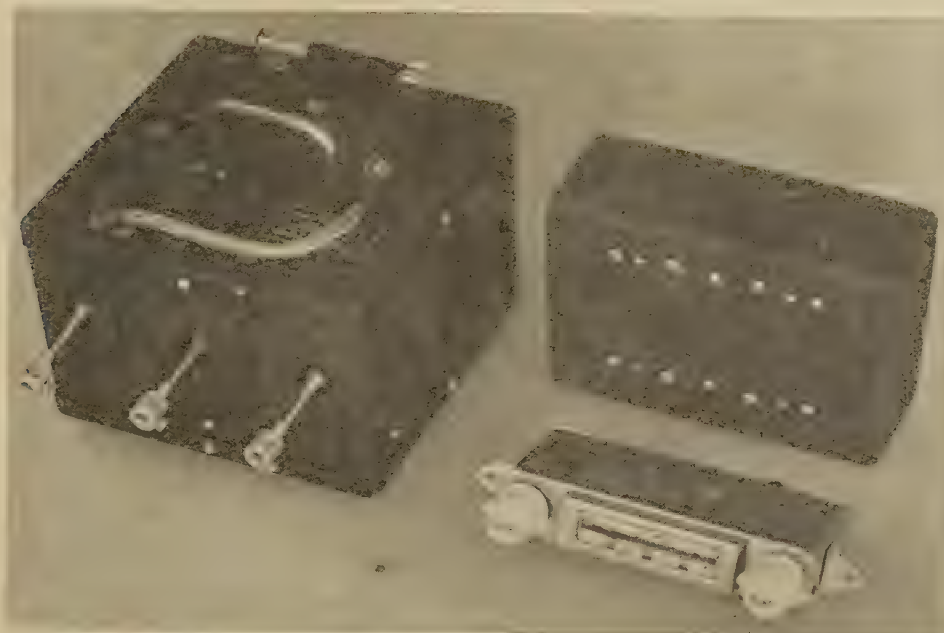


Fig. 443.—An Ekco All-wave Car Receiver.

Problems of Installation

A car radio set works under adverse conditions. The signal picked up by the aerial is small, mechanical vibration is relatively severe, the supply of power is rather restricted and there are temperature changes over a wide range. For purposes of comparison a car radio gives about twice the average output of a domestic set from a speaker roughly half the size. The driving power available is about a third of that used by an all-mains set, and the signal input is less than a quarter of that from an average aerial. As a result of the small input available the set must be designed to give high amplification. This, in turn, makes it prone to a great deal of interference. Matters are further complicated by the fact that the power supply to the set can be a major source of this interference.

The designer of the set takes these matters into consideration, and the construction is such as to minimise the effect of these disturbances, but that is the most he can do. The final success of the receiver depends on proper installation. Failing this, the performance will fall far short of that which should be realised.

The main problem of installation is that of providing a " clean " input to the set both from the aerial and from the power supply. This means that the aerial and tuning circuits must only deliver the required signal, and the D.C. for the valve heaters and the H.T. for their anodes must be free from random voltage variations. This apparently simple requirement is difficult to fulfil in practice, as the following will show.

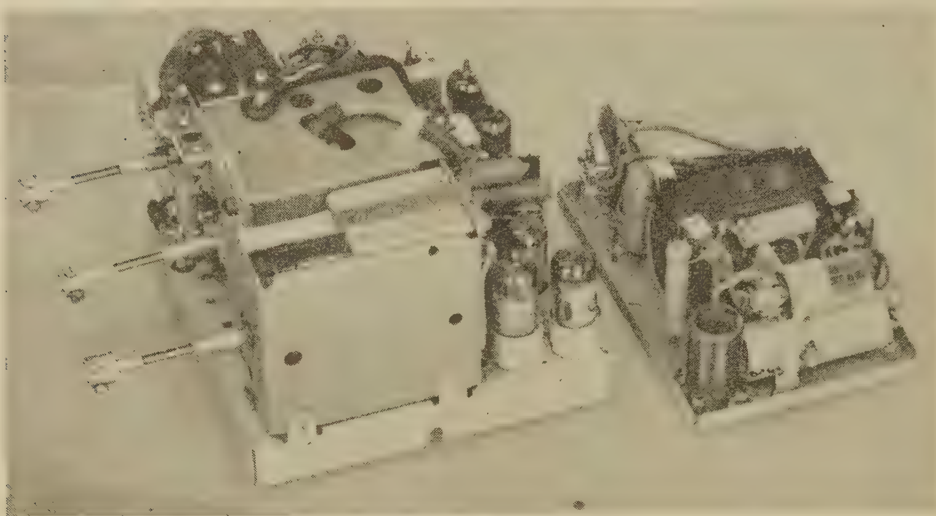


Fig. 444.—The Receiver shown in Fig. 443, but with the Screening Covers Removed.

A radio receiver works by reason of voltage changes on the valve grids. Those on the grid of the valve feeding the loudspeaker are considerable (30 volts or so), but those at the first valve are small (a few thousandths of a volt) and they occur about a million times per second. The wanted voltage changes—generally called the " signal "—are picked out from others by the tuned circuits in the receiver. These circuits cannot select a signal to the exclusion of all others, so if two broadcast stations transmit on nearly the same frequency the receiver will respond to both at once. There is then no means of suppressing one without removing the other.

Broadcast stations are not the only source of voltage changes that are accepted as a signal by a receiver. Practically anything that produces electrical sparks can transmit radio waves through space, and a car in motion is equivalent to about a dozen transmitters so far as the radio set is concerned. The transmitters involved are six plugs, a distributor, two

dynamo brushes, a contact breaker, a windscreen wiper, and so on. There may well be another dozen or so radio generators in the car body, brakes, and tyres, as well as in the power supply to the radio set itself.

These electrical disturbances are known collectively as interference and their source is nearly always a spark. Actually a spark is not the single flash that it appears to be, but a whole series of flashes taking place very rapidly. The size of the initial flash depends on the energy available. Succeeding flashes get smaller as the energy dissipates, and eventually they cease. The rapidity with which the flashes follow one another depends on the electrical size of the circuit. It may be anything from a few hundred to several million times per second.

Sparks carrying a good deal of energy often show several rates of oscillation simultaneously. The energy causing the spark train is eventually used up in the production of heat in conductors and the surrounding air and by radiation into space. This radiation spreads in all directions and some of it may reach the receiver aerial or supply leads. When that happens the receiver will respond just as it does to a broadcast. The result is a series of random noises from the loudspeaker that may easily be of sufficient intensity to obliterate any wanted signal. These disturbances cannot be rejected by the receiver; they must be prevented from reaching it.

Electrical Silencing

There are several ways in which this can be done. The entire set can be enclosed in a metal box. That screens the circuits, but disturbances can still reach the aerial. The modern all-metal construction helps in this respect because the aerial is fixed outside the body and the sources of interference are mainly inside. A noise limiter can be fitted to the set, but that tends to be effective only against intermittent interference. The best plan is to suppress the disturbance at the source and this is relatively easy—once the source is known. The aim is to prevent sparks occurring by fitting either a resistance that will dissipate the energy as heat, or a condenser that short-circuits the energy, or by preventing any current interruption taking place.

The resistance method is used on the ignition system. A single resistor of about 10,000 ohms can be wired in the lead to the distributor, or separate resistors can be placed close to each plug. Most set makers supply a resistor for this purpose as part of the equipment. The resistor is effective because it prevents a long train of sparks being formed. As soon as the initial spark takes place current flows through the resistor. That causes a voltage drop, so less energy reaches the plug for any subsequent sparks and the train is damped out. This occurs long before the next ignition period is due, so the engine performance is not disturbed. Some motorists report that the resistor tends to increase the liability of the plugs to soot up.

The condenser method is used on dynamos, contact breakers and similar apparatus. A resistor could not be used in the dynamo leads

because it would produce far too great a drop in voltage. A condenser across the brushes, or one from each live brush to ground, will have no effect on the voltage delivered to the accumulator but will act as a very low-resistance path to earth for the high-frequency disturbances. Condensers are also fitted across the contact breaker and can be applied to trafficators, windscreen wipers, etc., if desired.

The third or bonding method is used where and when required to suppress interference caused by the car structure itself. If two metal bodies are separated by an insulator, large voltage differences may develop as the result of relative movement such as is caused by vibration. The voltage may eventually reach a value sufficient to break down the insulation, or intermittent contact may take place. In either case a current flows and the resulting spark train causes interference. This effect may appear between parts of the body, between clutch plates and flywheel, brake drum and shoes, etc. The cure is to make good electrical contact between the parts. This is automatically done in a welded body, but some composite bodies can be very troublesome, especially when old.

Power-supply Interference

The sources of interference so far mentioned affect the input to the set by producing voltages in the aerial, but the power supply to the set itself can cause disturbance. The source of power for the radio set is the car battery; 24 volts is the highest likely to be used. The set needs about

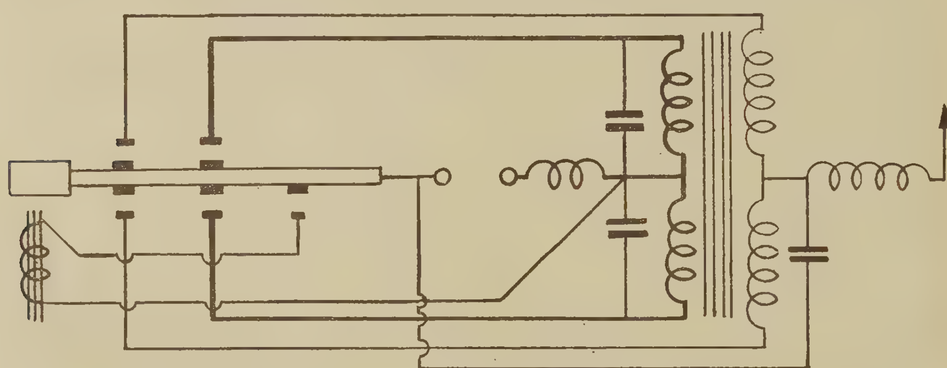


Fig. 445.—Diagram of the Circuit of a Vibrator for supplying H.T. Current.

300 volts for its valves and this can be produced from the battery only by mechanical means. The usual method is shown in the diagram, Fig. 445. A small reed is kept vibrating by an electro-magnet and serves to make and break two pairs of contacts about 100 times per second. The inner pair of contacts connects the battery alternately to opposite ends of the transformer. High voltages are generated in the secondary, rectified by the outer pair of contacts and taken from the centre tap to the H.T. lead of the

receiver. In some cases the reed has only one pair of contacts. Rectification is then done by a valve in the set.

The vibrator itself causes very little interference. It is thoroughly screened and, as the diagram shows, chokes and condensers are fitted in the L.T. and H.T. leads to confine disturbances to the vibrator itself. Buffer condensers are also fitted to minimise sparking at the contacts.

The average current drawn by the vibrator is in the region of 2 amperes, but it is not a steady drain like that of a lamp. When the primary contacts close, the momentary current may exceed 10 amperes. It will fall only slightly until the contacts open and then drop rapidly to zero (Fig. 446). This happens every time the contacts close. The leads from the battery to the vibrator will have a resistance of about ·01 ohm, so every time the vibrator takes current there will be a drop of ·1 volt. That is of no consequence so far as the vibrator itself is concerned, but if the valve heaters are wired as in Fig. 447 they also will be subject to these variations and so will the earth line of the set. Rapid voltage fluctuations in the earth potential of a set are equivalent to similar changes in the aerial. The result in this case is the introduction of " hash " into the receiver and the emission of noise from the loudspeaker. For this reason the set should be supplied with L.T. direct from the main junction box or, in extreme cases, from the accumulator itself.

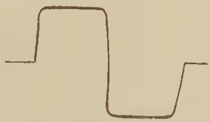


Fig. 446.—Waveform of Current in the Transformer Primary.

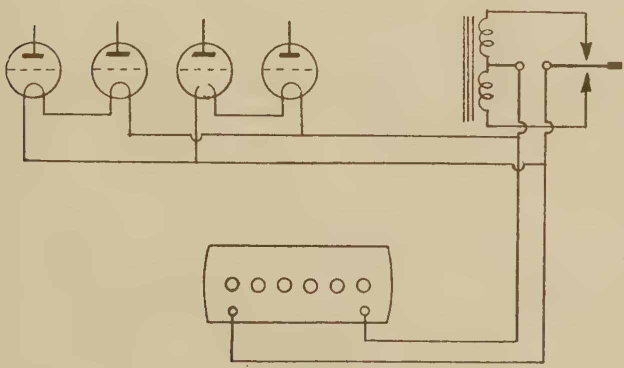


Fig. 447.—Incorrect Method of Wiring the Receiver to the Battery.

From the two preceding sections it will be clear that correct installation is most important if the set is to be free from serious interference. For good reception it is necessary that the signal-to-noise ratio should be as high as possible. The removal of all sources of interference, so far as may be, will reduce the noise, but a good aerial is also necessary.

Aerials

An effective aerial will greatly reduce the apparent noise level. In the absence of any signal the radio side of the set gives its maximum possible amplification. That is due to the action of the Automatic Gain Control. This works by reducing the gain of some of the valves in the set in proportion to the strength of the received signal; the stronger the signal the less it

is amplified. It follows that when a strong signal is being received the amplification will be relatively low, and any interference present will be amplified to this extent only. The signal strength depends on the power of the transmitter, its distance from the receiving aerial and the effectiveness of the aerial itself. Of the various factors affecting aerial pick-up, the most important is height. For the medium-wave band the aerial length should be in the region of 70 yards. This is clearly impracticable; 70 in. is as much as can be mounted on an ordinary vehicle.

There are three main types of car aerial: the vertical rod, the roof aerial in one of its forms and the under-chassis aerial. The vertical rod is simple, efficient, and not unsightly. When mounted at the rear of the car it is comparatively free from interference from the ignition system, but must be coupled to a dashboard set by a rather long lead. This introduces losses. Disadvantages of this aerial are that it is rather liable to damage, and the lack of rigidity tends to cause an unsteady signal.

The roof aerial may be either a rod or a loop mounted outside the car. For good signal pick-up the separation between rod and roof should be as great as possible. Limits to the height are generally set by appearance or by the mechanical stability of the rod.

The other type of roof aerial is a series of strips of metal braid fixed between the roof and the internal trimming. This aerial has much to commend it. Movement relative to the car is small, it is protected from the weather, is well separated from the main sources of interference and has a comparatively low impedance. It cannot be used in a metal roof.

The under-chassis aerial is much the same as the first type of roof aerial. It can be rather longer than the roof aerial, but it tends to be shielded by the metal of the car body and may give trouble through the accumulation of dirt on the insulators.

Aerial Connections.—Connection between the aerial and the set must be made by a length of screened wire. If the wire is not screened it acts as an extension of the aerial. Most of its length is inside the car, so it is shielded from the broadcast signal by the metal body and exposed to the full severity of any interference inside the car. It therefore adds practically nothing to the useful input, but a great deal to the interference. Shielding prevents this pick-up of interference. The shielding must be carried right from the input socket to the aerial insulator and must make good electrical contact with the metal of the body.

Practical Installation

Most manufacturers supply detailed instructions for the fixing of the actual receiver and these should be closely followed. Good electrical contact between the receiver case and the metalwork of the car is particularly important. Enamel must be scraped off the meeting surfaces so that true metallic contact is made.

Fixing of the control box is simple, but where flexible shafts are used

care should be taken that they run in a free curve without avoidable sharp bends or kinks. See that control knobs allow the proper range of movement and make sure that felt washers, if supplied, are in place.

Leads from the vibrator to the set are generally cabled and fitted with plugs. Power supply leads to the vibrator should be short and screened. Where no special instructions are given it is wise to run low-voltage leads direct to the main junction box rather than to take power from the nearest point on the car wiring.

Aerial fittings vary, but the general arrangement is a rubber or plastic bush which holds the aerial and insulates it from the car (Fig. 448). After the aerial is in place and before connecting the receiver, test from the aerial plug to the body of the car. There should be no circuit.

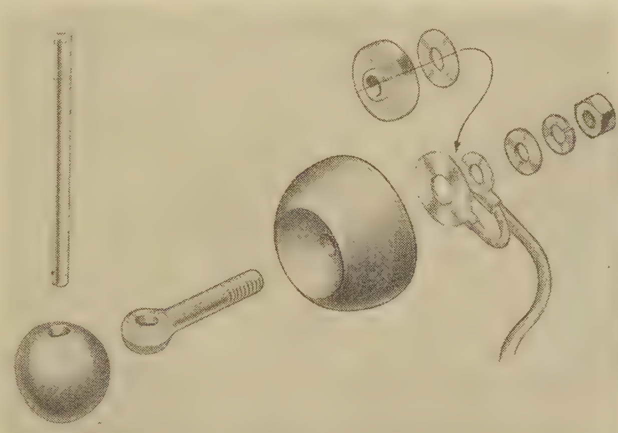


Fig. 448.—Method of attaching a Vertical Aerial to the Car Body.

Completing the Installation.—The aerial circuit of the receiver can now be trimmed and the station selection buttons or switches set as required. Suppressor resistors and condensers can now be fitted. The condenser across the contact breaker should be of as small a capacity as possible (·1 mfd. or so), but the dynamo condenser can be quite large. Condensers may be needed across the contacts of the voltage regulator if this is of the vibrating type. Sometimes it is necessary to screen leads such as those to the windscreen wiper motor.

Any suppressor device, resistor, condenser or choke must be fixed as close to the source of interference as possible, and the connecting leads must be short—an inch or so at most.

Output Problems

A set will sometimes prove unsatisfactory at high-volume levels. One cause may be vibration from the loudspeaker transmitted to sensitive parts of the set. Valves, tuning condensers and coils are the parts usually affected. The cure is to pack the offending component with felt wedges or strips, or to change the position of the loudspeaker.

Another difficulty encountered, particularly with multiple speakers, is a tendency for the set to become unstable. Touching the loudspeaker leads will often effect a temporary cure. When that happens it is fairly

safe to assume that there is electrical coupling between the aerial and the loudspeaker leads. High-frequency energy from the aerial can reach the output valve and be radiated from the loudspeaker leads. This radiation may reach the aerial and be again amplified. The effect thus builds up until the set becomes unstable. Cure and prevention consist in screening the loudspeaker leads and in arranging that they are well separated from the aerial or the lead-in. In obstinate cases a small condenser of ·002 mfd. or so can be wired across the loudspeaker leads as close to the set as possible, or from one lead to chassis. Experiment will show to which lead the condenser should be connected.

Maintenance of Radio Receivers

A certain minimum of attention must be given to radio equipment if it is to work satisfactorily. The great majority of failures are due to simple causes, such as defective aerial insulators, connections loosened by vibration, dirty or defective contacts to switches, failure of the power-supply vibrator or components. Faults such as these can be remedied easily.

The most necessary piece of equipment is a good multi-range test meter of the type familiar to radio service dealers. This will enable all voltages and currents to be checked and will reveal most of the common faults. Complete absence of signals, for example, would be investigated by first testing H.T. and L.T. voltages. If the H.T. is greater than normal, search should be made for a current lower than normal. For instance, the output valve may have failed partly or completely, or the output transformer may have developed an open circuit. If the voltage is normal and the output valve seems to be in order, touch the grid of that valve with the finger. The result should be a click or plop from the loudspeaker, indicating that the fault lies nearer the aerial end of the set. Tests may show that all valves are taking normal current except the first, a triode-hexode, and that this is taking a rather larger current than it should. The fault is then probably in the oscillator section of the valve. To test for this insert the meter (set to read 1 ma.) between the oscillator leak and earth. A reading of about ·5 ma. should be obtained. No reading indicates that the oscillator is not working. As the current is already high the fault cannot be an open circuit in the feed to the anode. Tests can therefore be made to the grid circuit. If the grid coils show continuity they are in order, but a very low resistance may be discovered between oscillator grid and earth. This indicates a defective grid condenser. When a new component is fitted the set should work correctly.

When elaborate tests are necessary they should be done only by a competent serviceman. Valve tests, re-alignment of the I.F. stages, adjustment of the oscillator tracking or of the performance of the A.G.C. circuits—all these need specialised equipment, and the successful handling of that is a matter requiring a good deal of experience.

CHAPTER 13

THE LAW AND THE MOTOR VEHICLE

EVERY motor-vehicle owner or user, nowadays, has so many legal obligations to fulfil that it is essential for him, or her, to become conversant with the more important points of law that are likely to be involved in connection with the everyday use of the vehicle in question.

Apart from the various legalities of the 1930 Road Traffic Act, the user should know the law as to registration, taxation, licensing, lighting, petrol storage.

There are now several hundred individual Regulations concerning motor vehicles, drivers, and allied subjects with which the motor engineer and operator is supposed to be familiar; moreover, fresh Regulations emanate at regular intervals and must be conformed to.

It is not possible, nor is it necessary, to go into the details of all existing Regulations, which date back for about thirty years. Instead, a summary of the most important Regulations with which the reader should be acquainted is given in the following pages.

To those seeking fuller information the original Regulations may be purchased from H.M. Stationery Office, Kingsway, London, W.C.2, or ordered through most booksellers. It may here be mentioned that a well-prepared and fairly comprehensive account of present-day road transport law is given in the book [1] mentioned in the footnote on this page. Further, at the end of this chapter will be found a list of selected titles and prices of those Regulations most likely to be needed by the motor engineer and garage proprietor.

Accidents

(*a*) *Accidents occurring in Motor Garages or Workshops* come within the scope of the Factory Act (section 4 in the Notice of Accidents Act). If a person involved in an accident in the workshop is disabled for more than three days from earning any wages, written notice must be given to the local inspector of factories by the employer or occupier of the workshop premises.

(*b*) *Accidents on the Road.*—Accidents, due to the presence of a motor vehicle on the road, which result in damage, or injury, to any person, vehicle, or animal, legally necessitate the driver of the vehicle stopping at

[1] *Road Transport Law*, L. D. Kitchin. (Iliffe, Ltd., Stamford Street, London, S.E.1.)

the time. If requested by any person having reasonable grounds for such request, the driver must give his name and address and also that of the owner, and the registration number of the vehicle.

Alternatively, the driver must report the accident at a police station, or to a police constable, as soon as reasonably practicable, but in any case within twenty-four hours of the occurrence.

In an accident involving only damage to one or more vehicles, if the drivers exchange their addresses it is not legally necessary to report the accident to a police officer, unless a charge is to be made against one of the drivers.

If the Minister of Transport decides to hold an inquiry into the cause of any accident, his representative may inspect the vehicle, and at reasonable time inspect the premises where it is kept.

Address

Under the Road Traffic Act of 1930, if a driver is alleged to have driven recklessly, dangerously, or carelessly, he must give his name and address to any person having reasonable ground for requiring the information. Refusal to give this, or the giving of a false name and address, renders the driver guilty of an offence.

Agricultural Machines (Locomotives and Tractors)

Vehicles used solely for the conveyance of produce of agricultural land occupied by the registered owner (or articles required for the purposes of the land) are granted reduced taxation by the Finance Act, 1928. Provisions are also made by the Act in question for the occasional conveyance of another person's agricultural produce, without increased licence fees.

Under Section 35 of the Highways Act, 1835, certain restrictions were imposed on the erection of machines and machinery within 25 yards of a highway. These restrictions do not, however, prohibit machines or motor vehicles from being used for purposes connected with agriculture, forestry, building operations, or the repair, maintenance, or construction of roads.

Alteration of Motor Vehicle

If any alteration is made to a car so as to alter its registered particulars, for example if it is painted another colour, notice of such alteration must be given to the council issuing the identification number; no fee is payable.

Alteration of Use

Where a licence has been taken out for a mechanically propelled vehicle for one kind of use, and it is afterwards put into other use, entailing a higher duty, this higher duty must be paid before or at the time of the first use. The licence must be surrendered to the council with the Registration Book, the difference of duty paid, and the amended licence obtained.

Where *alternative bodies* are used, the heavier one must be reckoned as the one for computing the unladen weight.

Aiding and Abetting

The offence of aiding and abetting applies to the various legal offences committed by the driver. Thus, a passenger (including the owner) in a motor vehicle can be convicted of aiding and abetting the driver in committing the offence of reckless driving.

Ambulance

Motor vehicles used solely as ambulances are exempt from licence duty but they must be registered.

Appeal

If a person is convicted of any offence under the Road Traffic Act, 1930, he, or she, has the right to appeal at the next Court of General Quarter Sessions.

Arrest

The driver of a motor vehicle who commits the offence of reckless, careless, or dangerous driving may be arrested by a police constable, whether in uniform or not, without warrant, unless he gives his name and address or produces his driving licence for examination. Under the Highways Act, 1835, a person who sees a vehicle being driven furiously to the danger of any person may arrest the driver without a warrant.

Brakes[1]

Under the 1937 Motor Vehicle Regulations, the following conditions are laid down, namely:

(1) Every motor car shall be equipped with an efficient braking system or efficient braking systems in either case having two means of operation so designed and constructed that notwithstanding the failure of any part (other than a fixed member or a brake-shoe anchor pin) through or by means of which the force necessary to apply the brakes is transmitted, there shall still be available for application by the driver to not less than half the number of the wheels of the vehicle brakes sufficient under the most adverse conditions to bring the vehicle to rest within a reasonable distance.

Provided that in the event of such failure as aforesaid it shall not be necessary for brakes to be available for application by the driver:

- (i) in the case of a motor car registered before October 1st, 1938, to more than two wheels;
- (ii) in the case of a vehicle having less than four wheels, to more than one wheel.

[1] See also " Parking Brakes " and " Servo Brakes."

(2) The application of one means of operation shall not affect or operate the pedal or hand lever of the other means of operation.

(3) In the case of vehicles registered on or after April 1st, 1938, and, as from October 1st, 1938, in the case of all vehicles, no braking system shall be rendered ineffective by the non-rotation of the engine:

Provided that this paragraph shall not apply in the case of the vehicles referred to in sub-paragraph (ii) of paragraph (7) hereof.

(4) All the brakes of a motor car which are operated by one of the means of operation shall be capable of being applied by direct mechanical action without the intervention of any hydraulic, electric, or pneumatic device.

(5) In the case of a motor car with more than three wheels where any brake-shoe is capable of being applied by more than one means of operation all the wheels shall be fitted with brakes all of which are operated by one of the means of operation:

Provided that—

(i) where a motor car has more than six wheels, at least four of which are steering wheels, it shall be a sufficient compliance with this paragraph if brakes are fitted to all the wheels other than two steering wheels which are situated on opposite sides of the vehicle, and all such brakes are operated by one of the means of operation,

(ii) where a motor car has more than four wheels and the drive is transmitted to all wheels other than the steering wheels without the interposition of a differential driving gear or similar mechanism between the axles carrying the driving wheels it shall be deemed to be a sufficient compliance with this paragraph if one means of operation operates the brakes on two driving wheels situated on opposite sides of the vehicle and the other means of operation operates brakes on all the other wheels required to be fitted with brakes by this paragraph, and

(iii) where means of operation are provided in addition to those prescribed by this Regulation such additional means of operation may be disregarded for the purposes of this paragraph.

(6) One at least of the means of operation shall be capable of causing brakes to be applied directly and not through the transmission gear to not less than half the number of the wheels of the vehicle:

Provided that in the case of a motor car having more than four wheels and registered before October 1st, 1938, it shall be deemed to be a sufficient compliance with this paragraph if one of the means of operation applies brakes directly and not through the transmission gear to not less than two of the wheels of the vehicle:

Provided also that where a motor car has more than four wheels and the drive is transmitted to all wheels other than the steering wheels without the interposition of a differential driving gear or similar mechanism between the axles carrying the driving wheels it shall be deemed to be a sufficient

compliance with this paragraph if the brakes applied by one means of operation act directly on two driving wheels on opposite sides of the vehicle and the brakes applied by the other means of operation act directly on all other driving wheels.

(7) For the purpose of this Regulation—

(i) in the case of a motor car registered for the first time on or after October 1st, 1938:

(*a*) except in the case of a motor car the unladen weight of which does not exceed one ton or which is a passenger vehicle constructed or adapted to carry not more than seven passengers exclusive of the driver, not more than one front wheel shall be included in half the number of the wheels of the vehicle for the purposes aforesaid;

(*b*) every moving shaft to which any part of a braking system or any means of operation thereof is connected or by which it is supported shall be deemed to be part of that system;

(ii) in the case of a motor car propelled by steam and not used as a public service vehicle, the engine shall be deemed to be an efficient braking system with one means of operation if the engine is capable of being reversed and is incapable of being disconnected from any of the driving wheels of the vehicle except by the sustained effort of the driver.

Heavy Motor Cars.—These must be equipped with two independent and efficient braking systems or with one efficient braking system having two independent means of operation, in each case so designed that, notwithstanding the failure of any part of any braking system, there shall still be available for application not less than half the number of the wheels of the vehicle brakes sufficient to bring the vehicle to rest within a reasonable distance.

In all cases the brakes operated by one system must be capable of being applied by direct mechanical action without the intervention of any pneumatic, electric, or hydraulic device.

Motor Cars not exceeding $2\frac{1}{4}$ *tons.*—In this case there must be two entirely independent and efficient braking systems (or one efficient system having two independent means of operation), in each case so designed and constructed that the failure of any single portion of any braking system shall not prevent the brakes on two wheels (or in the case of a vehicle having less than four wheels, on one wheel) from operating so as to bring the vehicle to rest within a reasonable distance. Provision is made that in a single system the two means of operation may be to the same cross-shaft and yet be independent.

It is also laid down that the brakes on these and also public service vehicles must operate by one of the means directly on to the wheels, i.e. not through the transmission gear, but in 1954 brakes operating on the driving shaft were authorised in the case of certain passenger vehicles. In all cases operation must be of a direct mechanical nature for one of these means, and therefore without the intervention of electric, pneumatic, or hydraulic device.

Invalid Carriages.—These require efficient braking systems; in each case the brakes must act on at least two of the wheels of the vehicle, and the brakes must be so designed and constructed that they shall bring the vehicle to rest within a reasonable distance.

Trailers.—Every trailer exceeding 2 cwt. (unladen) must have an efficient braking system acting upon at least two wheels in the case of a trailer having not more than four wheels, and at least four wheels in the case of a trailer having more than four wheels. The brakes must be so constructed that their application will prevent two at least of the wheels from revolving. In addition to the driver of the drawing vehicle, a person competent efficiently to apply the brakes of the trailer must be carried, unless the driver is in a position readily to operate the brakes of both vehicle and trailer. The braking system must also be capable of acting for parking purposes.

Automatic brakes, applied by the over-run of the trailer when the drawing vehicle stops, are permissible and do not require an additional person.

Motor Cycle Brakes

(1) Every motor cycle must be equipped with an efficient braking system or systems in either case having two means of operation so designed and constructed that notwithstanding the failure of any part (other than a fixed member or a brake-shoe anchor pin) through or by means of which the force necessary to apply the brakes is transmitted, there shall still be available for application by the driver to at least one wheel of the vehicle a brake sufficient under the most adverse conditions to bring the vehicle to rest within a reasonable distance.

(2) The application of one means of operation shall not affect or operate the pedal or hand lever of the other means of operation.

Careless Driving

The law requires that a person shall drive with due care and attention and with reasonable consideration for other road users. In this respect a first or second conviction does not necessarily disqualify the driver from holding or obtaining a licence.

Change of Ownership

This must be notified to the County Council authority issuing the licence to the old owner, and the new owner must send the Registration Book to them.

Chauffeurs and Servants
Armorial Bearings

Every driver employed by a garage proprietor or firm must possess a driving licence, and is personally responsible in the case of infringement of any of the motor laws.

The annual duty in the case of male drivers or chauffeurs is that of male servants, namely, 15*s.*, providing his time is substantially occupied in looking after and driving the car. If during the greater portion of the time he is occupied in work not coming under the definition of male servant's work he is exempt.

The annual duty for the use of armorial bearings on a carriage or motor is £2 2*s.*

Convertible Body

Where motor vehicles are fitted with convertible or alternative bodies the licence taken out must be that costing the highest amount applicable to any use made during the currency of the licence.

Dangerous Driving

The law states that "a person shall not drive recklessly, or at a speed, or in a manner dangerous to the public, having regard to all the circumstances of the case, including the nature, condition and use of the road and the amount of traffic which is actually on the road."

Destroyed Car

The licence duty on a car which has been totally destroyed may be allowed by transfer and issue of a new card to another car.

Dimensions of Vehicles[1]

There are certain limiting overall *lengths* for different types of motor vehicles, as follows:

	ft.	in.
Vehicles having four wheels	27	6
Vehicles having more than four wheels	30	0
Articulated vehicles	33	0
Any eight-wheeled articulated vehicle registered before January 1st, 1931	36	0

The overhanging of a heavy motor car, registered after August 15th, 1928, must not exceed $\frac{7}{24}$ of the overall length. The overhang of a motor tractor must not exceed 6 ft.

For heavy motor cars registered after October 1st, 1938, the overhang is limited to 50 per cent. of the wheelbase, as measured from the centre of the front wheels to the centre of the back wheels.

In the case of motor cars not over 20 ft. long, the overhang may be increased by 9 in. but must not exceed $\frac{7}{24}$ of the overall length.

There is no official *height limit* specified for goods vehicles and their loads, but public service vehicles must not exceed 15 ft. in height.

[1] See also the List of Regulations given at end of this chapter for amendments prior to 1951.

In regard to the limiting overall *widths*, these are as follows:

	ft.	in.
Locomotives	9	0
Motor Tractors	7	6
Heavy Motor Cars	7	6

Direction Indicators

These are not compulsory on any vehicle (1951), but if they are fitted they must conform to the official Regulation, No. 1872, 1953, which now legalises the use of front and rear flashing-light indicators.

Disabled Vehicles

If a vehicle is disabled in a street within the London traffic area, the owner and driver, or other person in charge, must remove it as soon as possible. A police constable in uniform is empowered to remove it himself or use the services of any other persons to remove it at the owner's expense.

Driving Licence

Before any person is allowed to drive a motor vehicle upon the highway, he or she must be provided with a driving licence; for motor vehicles used on private ground no licence is required.

Application must be made to the County Council, or County Borough in which the applicant resides. A fee of 5*s*. is payable for the driving licence and the latter must be renewed each year for a similar fee.

When the licence is received it must at once be signed by the applicant; failure to sign involves a legal penalty.

The minimum qualifying age for driving a motor cycle is 16 years; for a motor car, 17 years; and for a heavy motor vehicle, 21 years.

A declaration of physical fitness must be made when a driving licence is applied for (a special Form, supplied by the County Council Authorities, must be filled in). The applicant must state in his application whether he is suffering from any "prescribed disease or disability." Epilepsy, liability to sudden giddiness, or fainting, and inability to read an ordinary number plate 25 yards away (eyeglasses are permitted) constitute prescribed diseases.

Provisional or Learner's Licence.—Applicants for a first driving licence are required to pass an official driving test before a driving licence is granted. Full particulars of the test and the fees are given in The Motor Vehicles (Driving Licences) Regulations, 1937; the fees vary from 2*s*. 6*d*. to 7*s*. 6*d*. A provisional driving licence is issued to enable a learner to obtain instructions in order to pass the official test; this licence is valid for a period of three months.

A learner under instruction in a car must always be accompanied by a

person who has held a driving licence for at least two years, and the car must display the letter " L " both at the front and rear. When a learner considers that he or she has attained the required standard of proficiency application may be made on the official Form D.L. 26, which can be obtained from the local motor taxation office, and upon completion the Form together with a fee (usually 5*s.*) is forwarded to the Supervising Examiner for the district. The latter then arranges for an official driving test, which if successful enables the applicant to take out an annual driving licence. In the event of failure to pass the test, another test may be taken one month later; this procedure may be repeated until the applicant is successful in passing the official driving test.

One essential requirement for applicants is a thorough knowledge of the Highway Code; the official examiner invariably checks the driver's understanding of the more important items explained in the Code. The official test usually takes from 20 mins. to 30 mins., during which the applicant may be tested for any or all of the following: (1) Ability to start the engine. (2) To move off from rest in any direction. (3) To overtake, meet or cross other road traffic. (4) To make left- and right-hand turns. (5) To stop the vehicle in an emergency and bring it to rest on the correct part of the road. (6) To reverse the vehicle and enter a limited opening on the left- or right-hand side of the road. (7) To drive the car so as to face in the opposite direction with the aid of the gears. (8) To give the correct hand or mechanical signals when turning, stopping, passing other vehicles, etc., and (9) To conform to all road or police signals promptly and correctly, and to act appropriately to the signals or signs given by other road users.

An applicant for a provisional driving licence must also be able to read a motor-car number plate containing six letters and figures at a distance of 25 yards in good daylight, with the aid of glasses (if normally worn).

The learner's " L " plate consists of a red letter " L " on a white background. The height of the letter should be 4 in. and breadth of horizontal portion $3\frac{1}{2}$ in. The width of each limb should be $1\frac{1}{2}$ in.; the white background portion should measure 7×7 ins.

The driving licence must be produced on the request of a police officer, but alternatively the driver is allowed five days' grace in order to enable him to produce the licence at any police station he may specify.

If a police court orders a licence to be endorsed for a conviction it must be produced in court within five days.

Disqualification from holding a driving licence (as the result of a conviction) may be made by magistrates, but an appeal from refusal of licence can be made to the local magistrate's court. If a licence is lost a duplicate can be obtained on payment of 1*s.*

A driving licence is not transferable; it can only be used by the person to whom it is issued. It can, however, be used on any motor vehicle in the class for which the driver is licensed.

Driving off Highway

Under the Road Traffic Act, 1930, it is illegal to drive without lawful authority on to any common land, moor land, or any land not forming part of a road, except for a distance of 15 yards for the purpose of parking, or any bridle-way or footway. Exceptions to this requirement are made in the case of vehicles driven off the highway for the purpose of saving life, extinguishing fire, or meeting a similar emergency. This legislation does not prejudice local by-laws and the law of trespass.

Driving Mirror

Every motor vehicle (except motor cycles) must now be fitted with a rear-reflecting mirror, but motor vehicles drawing trailers are exempt if the person carried on the trailer has an uninterrupted view to the rear and is able to communicate with the driver. Interior mirrors are only legal when the rear windows are not obscured by blinds, etc.

Electric Vehicles

An electric vehicle weighing not more than 12 cwt. pays a fixed tax of £10; formerly this was £6. Commercial electric vehicles pay taxes which are graduated according to their unladen weights.

Excessive Noise

It is an offence to cause excessive noise (except in cases where this noise is accidental or temporary, not preventable by the exercise of diligence or care), whether through any defect or lack of repair or faulty adjustment in the motor vehicle or trailer; or through the faulty packing or adjustment of the load.

Fees

The following are the principal fees payable by owners, or drivers:

	s.	*d.*
Driving Licence	5	0
Driving Licence duplicate	1	0
Registration Book duplicate	5	0
Excise Licence duplicate	5	0
Amendment of Particulars on Register	No charge	
Copy of Entries on Register	1	0
Driving Test for Physical Fitness	10	0
Insurance Certificates	No charge	

Fire Engines

Where fire engines are kept by a local authority for use only in fire-brigade work, these are exempt from payment of Excise licence.

Fitness, Certificate of

It is an offence to run a public service vehicle without the owner holding a certificate of fitness in reference to it. Such a certificate must be produced before a Public Service Vehicle Licence is issued. Application for a certificate must be made to the Scotland Yard authorities (in London) or to the commissioners who depute the certifying officer of the district to see that it complies with official requirements and issue the certificate.

Any certifying officer can call on a public service vehicle to stop at any moment and submit to examination, or at any reasonable time may enter premises for the same purpose. The certificate may be revoked by a certifying officer if the vehicle is found to be out of order; this automatically suspends the licence.

A certificate of fitness may last for five years, but may be restricted by the certifying officer to one year.

No certificate of fitness is required for a hire car of less than eight seats.

In connection with the issue of goods vehicles licences A, B, and C under the provisions of the Road and Rail Traffic Act, 1933, that came into force on January 1st, 1934, it is made a condition of every licence that the authorised vehicles are maintained in a fit and serviceable condition. For this purpose and the observance of the provisions of the Road Traffic Act, 1930, the Ministry of Transport has appointed certain officials known as "examiners" to inspect any goods vehicles and, if he considers the latter unfit for service on the road, to prohibit its use until the defects have been remedied.

Fittings on Motor Vehicles

All fittings, e.g. parts and accessories of the car, must be in such a condition as not to cause, or be likely to cause, danger to persons carried thereon or to other road users. This applies also to weight distribution, packing and adjustment of loads.

Fire Extinguishers

A public service vehicle must carry fire-extinguishing apparatus (Section 2, Equipment and Use Regulations, 1931). Similar apparatus or a supply of sand must be kept in or near any *private garage* or place of storage of petrol.

Guard Rails

A Regulation that came into force on January 1st, 1933, provides that if the wheels on either side of the motor vehicle (locomotives and tractors excepted) have a clear space of more than 2 ft. between their nearest points, a guard rail, running board, or similar device must be fixed and effectively kept in condition to guard each space to within 15 in. of the ground.

Highway Code

The Ministry of Transport has issued a small booklet containing a list of recommendations to drivers of motor vehicles. This booklet is usually supplied free with the driving licence. Observance of its rules is not compulsory, however, but non-observance may tend to establish or negative liability in civil or criminal proceedings.

Horn

All motor vehicles (except heavy locomotives) must be fitted with a suitable device for giving audible warning of approach or position. When the vehicle is stationary on the highway no person shall use, or permit the horn to be used, except when its use is necessary for safety reasons. Further, in London and other restricted areas, where the 30 m.p.h. limit applies, horns must not be sounded between the hours of 11.30 p.m. and 7 a.m.

Horsepower Calculation

Prior to 1947, in the case of motor vehicles exceeding 8 cwt., unladen, the horsepower of their engines, for Treasury rating purposes, was estimated as follows:

The horsepower of any cylinder of an internal-combustion engine is deemed to be equal to the square of the internal diameter of the cylinder, in inches, divided by the numeral 2·5. In the case of a multi-cylindered engine the total horsepower is the sum of the horsepowers of all the cylinders.

If we denote the cylinder diameter by D inches, and the number of (equal) cylinders by N, then we have

$$\text{Treasury rating horsepower} = \frac{D^2 \times N}{2{\cdot}5}, \text{ or } \frac{2D^2N}{5}.$$

Example: What is the taxable horsepower of a four-cylinder engine of 2-in. bore?

Here D = 2 and N = 4, so that the horsepower $= \frac{2 \times 2^2 \times 4}{5} = 6{\cdot}4.$

At the horsepower rate of taxation for motor cars, the owner is required to pay annually 25*s.* per Treasury rating horsepower, but in the case of cars registered after January 1st, 1947, the horsepower rating method was superseded by the *cubic capacity* one described on page 439.

If the estimated horsepower is not a whole number, i.e. a whole number followed by a decimal part, the horsepower is reckoned as the next higher whole number.

Thus if the rated horsepower is 6·4, the car will be taxed as 7 horsepower and will pay an annual tax of £5 5*s.*

The horsepower of any mechanically propelled vehicle deriving its

power wholly *from a steam engine* shall be taken to be proportional to the effective heating surface of the boiler supplying steam to such engine, at the rate of 1 horsepower for every 3 sq. ft. in such effective heating surface, and the effective heating surface shall be taken to be:

(*a*) In the case of a boiler having horizontal or approximately horizontal tubes, the whole of that surface of the tubes which is exposed to the flame or hot gases;

(*b*) In the case of a boiler having vertical or approximately vertical tubes, half of that surface of the tubes which is exposed to the flame or hot gases.

Any mechanically propelled vehicle deriving its motive power from an *electric motor* or motors shall be deemed to be of 6 horsepower.

In measuring cylinders and boilers, and in calculating horsepower, fractions of inches and feet and fractions of a unit of horsepower are to be taken into account. Provided that in the final calculation of horsepower a resultant fraction of less than ·1 of a unit of horsepower shall be omitted.

Where it appears that, in consequence of the exceptional design or construction of the engine of any mechanically propelled vehicle, the horsepower as calculated under this Regulation is substantially less than the average power which the engine would develop in continuous use on the road if there were no restrictions on speed other than those imposed by the vehicle itself, then such average power shall be taken as the power of the vehicle.

Cubic Capacity Rating Method

In the 1945 rating method, for taxation purposes, it is reckoned that a petrol engine develops 1 horsepower for every 100 cubic centimetres of cylinder capacity and it is taxed at the rate of £1 per 100 c.c. Actually, a modern car engine will develop 3 to 4 brake horsepower per 100 c.c., but the above method is a simple and convenient one.

In the case of a four-cylinder engine of 56·7 mm. bore and 100 mm. stroke, the total cylinder capacity works out at 1,009 c.c., whereas the Treasury rating is 7·98 h.p. Thus on the cubic capacity method of taxation the owner will pay £10 per annum, as against £8 per annum on the previous Treasury rating method.

The cubic capacity is given by the following formula:

$$\text{Cubic capacity} = \frac{3{\cdot}1416 \times (\text{diameter})^2 \times (\text{stroke}) \times (\text{No. of cylinders})}{4}$$

where the diameter and stroke are expressed in centimetres.

Flat Rate Licence Fee

In 1947 a new Act was passed, whereby all new motor cars registered on and after January 1st, 1947, were required to pay an annual licence fee

of £10 per vehicle, irrespective of the horsepower rating. In January, 1953, this flat rate was increased to £12 10*s*. for all motor cars.

Hours for Drivers

Under the provisions of the Road and Rail Traffic Act, 1933, it shall not be lawful for any person to drive, or cause or permit any person employed by him or subject to his orders to drive, so that the driver has not at least 10 consecutive hours for rest in every 24 hours calculated from the commencement of any period of driving. In this respect the following shall not be treated as being time which the driver has for rest:

(1) Time during which the driver is bound by the terms of his employment to obey the directions of his employers. (2) Time during which the driver is bound by the terms of his employment to remain on or near the vehicle. (3) Time during which the vehicle is at a place where no reasonable facilities exist for the driver to rest away from the vehicle.

Identification Marks

When a motor vehicle is registered it is assigned certain letters and numbers. Usually the letters indicate the county in which the vehicle is registered. The number serves to identify the vehicle.

This *Identification Mark and Number* refers to the particular vehicle during the whole of its life; it is therefore not transferable to any other motor vehicle.

The registration letters and number assigned to a motor vehicle may be exhibited in white on a black background, and must be fixed at both the front and rear of the machine or vehicle.

The alternative methods of exhibiting these include a painted plate, a flat unbroken portion of the surface of the machine, e.g. a mudguard or a plate constructed of cast or pressed aluminium having raised letters and figures.

All letters and figures must be firmly fixed and rendered incapable of detachment from their base plate. It is not allowable to have ornamentation in the vicinity of the letters and figures.

The following are the legal requirements for number plates:

(*a*) Each plate must bear upon it the fixed index mark and registration number entered in the Register in respect of the machine. The letters and figures may be displayed in either of the two alternative forms given in Fig. 449.

(*b*) All letters and figures must be $2\frac{1}{2}$ in. high; every part of every letter and figure must be $\frac{3}{8}$ in. broad; and the total width of the space taken by every letter or figure, except in the case of the figure 1, must be $1\frac{3}{4}$ in. The space between adjoining letters and adjoining figures must be $\frac{1}{2}$ in., and there must be a margin of at least $\frac{1}{2}$ in. between the nearest part of any letter or figure and the top, bottom, and sides of the black surface upon which the identification mark is inscribed.

(*c*) Where the identification mark is arranged in accordance with Diagram No. 1, the space between the upper and lower line must be $\frac{1}{2}$ in. Where the identification mark is arranged in accordance with Diagram No. 2, the space between the letters and the figures must be 1 in.

(*d*) In regard to *three-wheelers and motor cars* the following are the legal requirements:

(1) If the identification mark is so constructed and used that it is illuminated by transparency or translucency, the letters and figures must all, when so illuminated during the hours of darkness, appear, in the case of the front identification mark, white, and in the case of the rear identification mark either white or red; if they appear red, no other lamp showing to the rear, a red light need not be carried.

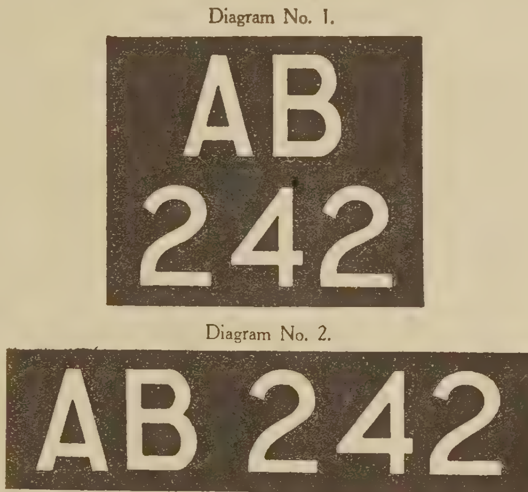


Fig. 449.—The Official Registration Letters and Numbers.

(2) The identification mark may, at the option of the owner, be displayed in either of the shapes shown in Fig. 449.

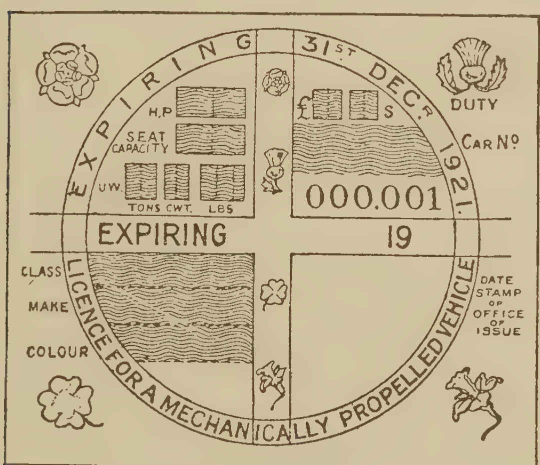


Fig. 450.—The Official Form of Licence Card.

(3) All letters and figures must be $3\frac{1}{2}$ in. high, every part of every letter and figure must be $\frac{5}{8}$ in. broad; and the total width of the space taken by every letter or figure, except in the case of the figure 1, must be $2\frac{1}{2}$ in.

(4) The space between adjoining letters and between adjoining figures must be $\frac{1}{2}$ in., and there must be a margin between the nearest part of any letter or figure and the top or bottom of the black surface upon which the identification mark is inscribed of at least $\frac{1}{2}$ in., and between the nearest part of any letter or figure and the sides of the black surface of at least 1 in.

(5) Where the identification mark is arranged in accordance with

Diagram No. 2, the space between the upper and lower line must be $\frac{3}{4}$ in. Where the identification mark is arranged in accordance with Diagram No. 2, the space between the letters and the figures must be $1\frac{1}{2}$ in.

(*e*) Every motor vehicle must carry its Inland Revenue or Excise Licence on the near side, either on the body or on the windscreen glass at the near side (Fig. 450).

If on the body it should be placed sufficiently high to enable it to be read without stooping down. It should be not less than 2 ft. 6 in., or more than 6 ft. 6 in., above ground level.

In regard to the licence card, this takes the form shown in Fig. 450; this diagram is reproduced at two-thirds the full size. The licence card is issued in different colours each quarter, or year, in order to render identification of the period of issue of the licence easier.

Form of Holder for the Licence

The holder must be of metal, and weatherproof. It must be either circular, or rectangular with crossbars, and conform to the following dimensions:

Circular Pattern without Crossbars.—*Licence Tray.*—The licence of standard pattern, when cut along the outline of the outer of the two circles, should fit neatly into a sheet-metal tray of suitable thickness, having a turned-up edge of sufficient depth to hold the licence and a stout cover of transparent white glass.

Ring Cover.—A circular ring of sheet metal shaped to fit down closely on the tray, and adapted for fixing by screws, bolts, or otherwise, to the vehicle in the prescribed position. A rubber packing ring should be arranged to fit between the ring cover and the cover glass and tray so as to render the whole carrier weatherproof.

Dimensions.—The aperture within the ring cover should clearly exhibit the whole of the licence lying within the inner circle of the licence, and should have a diameter of $2\frac{11}{16}$ in.

Rectangular Pattern with Crossbars.—*Licence Tray.*—A sheet-metal tray of suitable thickness, having a turned-up edge all round, of a depth sufficient to hold the full-size standard licence ($3\frac{27}{32}$ in. long and $3\frac{9}{32}$ in. wide) and a stout cover of transparent white glass.

Cover Frame.—A cover frame, formed out of sheet metal, should be shaped to fit down closely on to the licence tray, and adapted for fixing by screws, bolts, or otherwise, to the vehicle in the position previously described.

A rubber packing ring should be arranged to fit between the cover frame and the cover glass and tray, so as to render the whole carrier weatherproof.

Dimensions.—The main aperture within the cover frame should be $3\frac{11}{16}$ in. long and $3\frac{1}{16}$ in. wide, and be bisected axially by two bars intersecting at right angles, so as to leave four rectangular openings, each $1\frac{3}{4}$ in. long and $1\frac{13}{32}$ in. wide, clearly exhibiting the licence.

When a new licence is issued or the old licence has expired the latter should be destroyed by the owner.

All licences must be kept clean so as readily to be seen when required for inspection purposes.

Goods Vehicle Licence Cards

Under the Regulations of the Road and Rail Traffic Act, 1933, all goods vehicles must be licensed. The licences issued are of three classes, as follows: (A) Public Carriers' Licences; (B) Limited Carriers' Licences, and (C) Private Carriers' Licences. Licence (A) entitles the holder to use the authorised vehicles for the carriage of goods for hire or reward, or for the carriage of goods for or in connection with his business as a carrier of goods, whether by road transport or by any other means of same, but it is a condition of the licence that no vehicle which is for the time being an authorised vehicle shall be used for the carriage of goods for or in connection with any other trade or business carried on by him except such storage or warehousing of goods as may be incidental to his business as a carrier.

A limited carriers' licence (B) entitles the holder to use the authorised vehicles as he thinks fit from time to time, either for the carriage of goods for or in connection with any trade or business carried on by him, or, subject to any conditions which the licensing authority, in the exercise of his discretion to attach conditions to a B licence, may attach to the licence, for the carriage of goods for hire or reward. A private carrier's licence (C) entitles the holder to use the authorised vehicles for the carriage of goods for or in connection with any trade or business carried on by him subject to the condition that no vehicle which is for the time being an authorised vehicle shall be used for the carriage of goods for hire or reward. It is stipulated, however, that the licensing authority may, in a case of emergency and subject to such conditions as he thinks fit to impose, authorise the holder of a C licence to use an authorised vehicle for the carriage of goods for any person to whom he lets the vehicle, if the authority is satisfied that the needs of that person cannot conveniently be met from other sources.

The duration periods of A, B, and C licences are 5, 2, and 5 years respectively. Short-period licences may, however, be obtained for respective periods of 12, 6, and 3 months.

The following are the fees for the different classes of licence:

A Licence, per vehicle	£7 10*s*.
B " " "	£3 10*s*.
C " " "	£1 5*s*.

Fees can be paid for short-term licences, variations, and licences with short currency terms.

The licence cards for goods vehicles will be similar to those at present in use for private cars, but are overprinted with the letter " A " in red and " B " in blue. Other details are written in on the cards.

The " B "and " C " hiring margin licences are in the same form as the " A " licences, which has the big letters overprinted in red, but overprinted in blue and yellow, respectively.

Certain vehicles that have been granted a certificate " C " are required to carry licence number plates having a large letter " C " in addition to the index marks and number.

As alterations are occasionally made in connection with Goods Vehicle Regulations, the reader should ascertain from the local licensing authority the latest additions or amendments.

Insurance (Compulsory)

It is now compulsory for every motor-vehicle user, including motor cyclists, to take out an Insurance Policy for Third-party Risks. This insures the user against third-party claims in respect of death or bodily injury. Damage to property is excluded. In this connection it is important for the motor user to remember that some insurance policies are invalidated if the driver is unlicensed at the time. It is essential that the driver's licence (5*s.*) should be renewed on or before the date of expiry.

The motorist is issued with a Certificate of Insurance by his Insurance Company when the premium is paid. This is in addition to the cover note and the usual policy. *The certificate in question must be produced*, or sent to the County Council Authority when applying for a quarterly or yearly licence; this constitutes a proof of the applicant's compliance with the law. The certificate should be kept either on the person, or on the motor vehicle, as *it must be produced on request by a police constable.* Alternatively, it can, however, be produced within five days at any police station the owner may specify.

Where an accident occurs, owing to the machine *causing personal injury* to another person, if the driver is unable to produce his certificate at the time he must report the accident to a police station or to a police constable as soon as possible, and in any case within twenty-four hours of the accident, and must produce his insurance certificate. If not available he may produce it within five days at any police station he may specify.

Leaving Vehicle with Engine Running

It is an offence to leave any motor vehicle on a public highway, unattended, with the engine running. In all cases where a vehicle is to be left unattended the engine should be switched off and the hand brake applied.

Lighting Requirements

Front Lamps.—The law requires that motor cars and motor vehicles, other than those hauling trailers, must carry two lamps in front showing white lights, and that such lamps must be fixed on opposite sides, so that no part of the vehicle or its equipment shall extend more than 12 in. beyond the centre of the lamp. The sidelamps of cars should fulfil these conditions, but the headlamps (except where no sidelamps are fitted) need not.

Any red light showing towards the front of the car is prohibited.

Further, the front lamps must be kept in efficient condition when the vehicle is on the road whether travelling or stationary, during the hours of darkness; also, they must be of about the same power and at the same distance from the ground.

In addition to the two front lamps it is now lawful to carry not more than *two lamps of a moving character*, providing the angle through which the beam of light is moved shall not exceed the angle through which the front wheel of the vehicle, on the side to which the vehicle is being steered, is turned for the purpose of steering and the centre of any such moving lamps shall not be more than 3 ft. 3 in. above the ground.

In reference to the *Hours of Darkness*, these are defined during summer time as between one hour after sunset and one hour before sunrise, and for the remainder of the year as half an hour after sunset and half an hour before sunrise.

During the hours of darkness the rear number plate must be illuminated.

Further regulations in regard to lamps were issued under the Road Vehicles Lighting Regulations, 1936. Among the more important provisions were the following ones:

(*a*) Not more than two movable lights may be carried, although there does not appear to be any restriction in regard to the number of *fixed* white lights in front.

(*b*) *Parking of vehicles* without lights may, in certain instances, be permitted by the Chief Officer of Police.

(*c*) Motor bicycles must, normally, have lamps lighted even when stationary, but a motor bicycle need have no lamp at all if it is being wheeled by a person on foot as near as possible to the left-hand edge of the carriage-way.

(*d*) *Anti-dazzle regulations* are issued containing detailed provisions concerning electric lamps on all motor vehicles first registered on or after October 4th, 1936, and, after October 3rd, 1937, to all vehicles irrespective of their date of registration.

(*e*) A rear white surface was made compulsory with the rear red light for vehicles restricted to 20 m.p.h. other than public service ones. It must be of not less than 12 sq. in. with its centre not exceeding 3 ft. 6 in. from the ground, so that no part shall project more than 30 in.

(for bicycles, 20 in.) to the rear and so that 6 sq. in. at least of the white surface shall be on the off side of the centre line of the vehicle, and not less than 6 in. shall be over 10 in. above the ground. It is mentioned that polished aluminium or chromium plating can be used for the white surface.

1950 Lighting Requirements.—Headlamps must be switched off when the vehicle is stationary, except in traffic stops.

There is no restriction in regard to the candle-power (wattage) of headlamp bulbs, provided they do not dazzle a person at 26 ft. from the vehicle with an eye level above 3 ft. 6 in.

Fog Lamps.—By an Order of 1950, if a lamp with a permanently fixed beam is fitted, e.g. a foglamp, it must be mounted at a height of 2 ft. 2 in. above the ground. If a lamp is mounted at less than 2 ft. above the ground, it must not be used except in fog or during a snowfall.

Swivelling Headlamps.—These are permitted, but the centre of each lamp must not be more than 3 ft. 3 in. above the ground.

Stop Lights.—These are not compulsory, but if fitted must be red or amber, and placed on the centre line or to the right of this line.

1953 Rear Lighting Regulations.—The Road Transport Lighting Act of 1953 laid down that all motor vehicles, other than solo motor cycles and bicycles (which must have one rear red lamp and one red reflector) must have two red reflectors fitted, from October 1st, 1954.

Existing pedal cycles and tricycles, including motor-assisted bicycles not exceeding 50 c.c. engine capacity, must have a red lamp fitted by October 1st, 1955, and all other existing vehicles not included in the motor-vehicle category, by October 1st, 1956.

The red reflectors, if circular, must be not less than 1½ in. in diameter; for any other shape, not less than the equivalent area (1·77 sq. in.).

It is laid down that motor vehicles, except motor cycles (solo or sidecar), bicycles and a few special classes must have two rear red lamps of not less than 2 in. diameter; for motor cycles and bicycles, one of 1½ in. diameter. With the exception of motor cycles not exceeding 250 c.c., the lamps must have bulbs not less than 6 watts. The lamps must be wired so that if one lamp goes out the other will remain alight.

On motor vehicles the rear lamps must be placed, one on each side, not less than 21 in. apart and not more than 16 in. from the outer edges of the vehicle in the case of new vehicles, and not more than 24 in. in the case of existing vehicles (October 1st, 1953). The lamp and reflector on one side must be the same height as the lamp and reflector on the other side. The rules also apply to rear reflectors. For both rear lamps and reflectors these must not be more than 3 ft. 6 in. nor less than 15 in. from the ground, and not more than 30 in. from the tail end of the vehicle. Motor cycles and bicycles must have one rear lamp and one reflector on the centre line, or off side, not more than 20 in. from the tail end. Sidecars must have one rear lamp and also one reflector within 16 in. of the outer edge on the near side.

Goods vehicles exceeding 30 cwt. are required to have two rear lamps, and each lamp must not be more than 30 in. from the outer edge of the vehicle; each of the two reflectors must not be more than 16 in. from the outer edge. The maximum height is 3 ft. 6 in. for lamps and 4 ft. 6 in. for reflectors. Both lamps and reflectors on new vehicles (October 1st, 1954) must be at least 15 in. above the ground.

For buses and coaches, vehicles registered before October 1st, 1954 were not required to carry a second rear lamp; the single rear lamp must be on the centre line or off-side, and there is no limit to the maximum height. Two reflectors must, however, be fitted. New buses and coaches registered after October 1st, 1954, were required to have two rear lamps and two reflectors. Horse-drawn vehicles must have two rear lamps and two reflectors.

Licence Fees

The annual licence fees on motor vehicles are graded in the following manner:

(1) Motor Cycles, according to cylinder capacity.

(2) Motor Tricycles, if under 8 cwt. (unladen) and Sidecars come into the motor-cycle class.

(3) Motor Cars, according to horsepower.

(4) Commercial Vehicles, according to weight.

(5) Hackney Carriages, according to seating capacity.

The following were the rates in force in 1949:

1. *Motor Bicycles* (including motor scooters and cycles with an attachment for propelling the same by mechanical power) not exceeding 8 cwt. in weight unladen:

	Rate of Annual Duty		
		s.	d.
Bicycles:			
Where the cylinder capacity of the engine:			
(*a*) Does not exceed 150 cubic centimetres		17	6
(*b*) Exceeds 150 c.c. but does not exceed 250 c.c.	£1	17	6
(*c*) Exceeds 250 c.c.	£3	15	0
Bicycles, if used for drawing a trailer or sidecar, an *additional* sum of	£1	5	0
Tricycles (three-wheelers)	£5	0	0

2. *Invalid Carriages.*—Vehicles (including cycles with an attachment for propelling the same by mechanical power) not exceeding 5 cwt. in weight unladen, adapted and used for invalids

for invalids		5	0
Bicycles which are electrically propelled		17	6
Vehicles (other than mowing machines) with more than three wheels, not made for the carriage of a driver or passenger	£3	0	0

3. *Hackney Carriages.*—Vehicles being hackney carriages as defined in Section 4 of the Customs and Inland Revenue Act.

On January 1st, 1946, a new method of taxation for hackney carriages came into force, which represented savings on the previous system. The new rates are as follows:

Seating Capacity	*Rate* £ s.	*Seating Capacity*	*Rate* £ s.	*Seating Capacity*	*Rate* £ s.	*Seating Capacity*	*Rate* £ s.
8	12 0	21	38 0	33	58 16	45	73 4
9	14 0	22	40 0	34	60 0	46	74 8
10	16 0	23	42 0	35	61 4	47	75 12
11	18 0	24	44 0	36	62 8	48	76 16
12	20 0	25	46 0	37	63 12	49	78 0
13	22 0	26	48 0	38	64 16	50	79 4
14	24 0	27	49 12	39	66 0	51	80 8
15	26 0	28	51 4	40	67 4	52	81 12
16	28 0	29	52 16	41	68 8	53	82 16
17	30 0	30	54 8	42	69 12	54	84 0
18	32 0	31	56 0	43	70 16	55	85 4
19	34 0	32	57 12	44	72 0	56	86 8
20	36 0						

For the purpose of this paragraph the number of persons mentioned does not include the driver of the vehicle and the seating capacity is reckoned as 16 linear inches per seat.

4. *Commercial Vehicles.*—A number of important changes in the mode of licensing commercial vehicles and in the licence fees came into operation on January 1st, 1934. These alterations were generally in the form of increased fees for the heavier goods vehicles and an increased tax on high-speed oil-engine vehicles.

In addition to these changes in the licensing scales there was also introduced an entirely new system of licensing goods vehicles under the provisions of the Road and Rail Traffic Act, 1933.[1] The new method of licensing goods carriers should not in any way be confused with the increased licence fees for commercial vehicles, as it is an entirely separate matter.

The taxable vehicles are divided into five different classes, applicable respectively to (A) Petrol and Oil-engine Vehicles, (B) Agricultural Vans and Lorries, (C) Tractors for General Haulage, (D) Steam Vehicles, and (E) Electric Vehicles.

Each class of vehicle is then taxed according to its *Unladen Weight*. The fees increase with the unladen weight.

On January 1st, 1946, a new method of taxation for petrol- and oil-engine goods vehicles came into force. Previously, a higher tax was charged on vehicles fitted with solid instead of pneumatic tyres, but now the solid tyre for commercial vehicles has been superseded by the latter type. The present system of petrol- and oil-engine goods vehicles is as follows:

Type	*A*	*E*	*Type*	*A*	*E*	*Type*	*A*	*E*
	Petrol and Oil	*Electric Vehicles*		*Petrol and Oil*	*Electric Vehicles*		*Petrol and Oil*	*Electric Vehicles*
Wt. Unladen not exceeding	*Rate*	*New Rate*	*Wt. Unladen not exceeding*	*Rate*	*New Rate*	*Wt. Unladen not exceeding*	*Rate*	*New Rate*
	£ s.	£ s.	tons	£ s.	£ s.	tons	£ s.	£ s.
12 cwt.	10 0	10 0	2¾	32 10	27 10	5	70 0	40 0
15 cwt.	15 0	15 0	3	35 0	30 0	5¼	75 0	41 5
tons								
1	15 0	15 0	3¼	38 15	31 5	5½	80 0	42 10
1¼	17 10	16 5	3½	42 10	32 10	5¾	85 0	43 15
1½	20 0	17 10	3¾	46 5	33 15	6	90 0	45 0
1¾	22 10	18 15	4	50 0	35 0	6¼	95 0	47 10
2	25 0	20 0	4¼	55 0	36 5	6½	100 0	50 0
2¼	27 10	22 10	4½	60 0	37 10	6¾	105 0	52 10
2½	30 0	25 0	4¾	65 0	38 15	7	110 0	55 0

[1] See p. 465.

Trailers.—Additional duty is levied for drawing a trailer:

(*A*) Vehicles used by travelling showmen £10

(*B*) Other vehicles:

Unladen weight of drawing vehicle not more than $2\frac{1}{2}$ tons . £10
Exceeding $2\frac{1}{2}$ tons but not more than 4 tons . . . £15
Exceeding 4 tons £20

An articulated vehicle is treated as an ordinary vehicle, not a vehicle with trailer.

Exemptions from Taxation.—Vehicles which are exempt from taxation include fire engines or local authority fire service, ambulances, road rollers, haulage of lifeboats (only), for clearing snow (only), road repair, or construction purposes (only) (up to 5 cwt.).

Trailer tax is not payable for road gritting vehicles, or on trailers for farm implements and snow-plough trailers and gas-producer trailers.

Private Motor Cars.—From January 1st, 1953, all cars, irrespective of horsepower or date of manufacture, pay a flat rate of £12 10*s.* per annum.

Electrically propelled vehicles are taxed at £7 10*s.* per annum.

Quarterly licences are issued for all motor vehicles at $27\frac{1}{2}$ per cent. of the full year's duty.

Licences are also granted for the last two months of any quarterly period, and for the last month of a similar period.

The fees are, respectively, two-thirds and one-third of the quarterly amount.

Thus it is possible to obtain a licence for the period February 1st to March 24th, or for the period March 1st to March 24th.

It is not generally known that if a quarterly licence is surrendered at or before the end of the first or second month the fee for the unexpired portion (less a fee of 10*s.*) will be remitted.

Similarly, yearly licences can be surrendered and the fee for the unexpired whole months (less 10*s.*) remitted.

If a vehicle, although licensed, has not been used on a public road, a full refund may be obtained at any time.

The official quarterly periods are January 1st to March 24th, March 25th to June 30th, July 1st to September 30th, and October 1st to December 31st.

A fortnight's grace is allowed for the renewal of yearly or quarterly licences, but if the car is used during this period of grace it must be licensed, otherwise the owner is liable to a penalty.

Markings on Vehicles

The unladen weight and maximum legal speed when not drawing a trailer must be marked conspicuously on the near-side of heavy motor cars. The unladen weight and maximum permissible speed of a tractor when drawing a trailer must be marked in a similar manner. Locomotives must also be marked with their unladen weights.

Mirrors

It is laid down in the Motor Vehicles Regulations (Construction and Use), dated March 24th, 1937, that every motor vehicle, other than a motor cycle, shall be equipped either internally or externally with a mirror so constructed and fitted to the motor vehicle as to assist the driver if he so desires to become aware of traffic to the rear of the vehicle:

This Regulation does not apply to: (i) motor cycle; (ii) land locomotive; (iii) land tractor; (iv) pedestrian-controlled vehicle; (v) motor vehicle drawing trailer, if a person is carried on rear with uninterrupted view to the rear and such person is provided with means of communicating to the driver the effect of signals given by other drivers of vehicles in the rear; (vi) works truck, if driver has clear rear view.

Number Plates

It is a legal offence if the number plate is not properly fixed or if it is in any way obscured or rendered not easily distinguishable, unless the driver has taken reasonable steps to prevent this. Dirty number plates and number plates obscured by luggage, or pillion-seat riders (in the case of motor cycles), come under this heading.

Overall Dimensions of Vehicles

It was laid down in 1953 that the overall length of any motor vehicle, excluding articulated vehicles, or a public service vehicle, should not exceed 27 ft. 6 in. in the case of four-wheeled vehicles, nor 30 ft. in the case of a vehicle with more than four wheels. The overall height of a public service vehicle must not exceed 15 ft. The overall width of a motor car must not exceed 7 ft. 6 in.

Overtaking Vehicles

When overtaking or passing another vehicle the driver should always overtake on his off-side, although in certain cases, e.g. when passing stationary tramcars, it is permissible to pass on the near-side.

Parking at Night

With certain exceptions, stationary vehicles are required to stand with the near-side next to the kerb, at night, so that *no vehicle must park with its lights facing vehicles* coming towards it, on the same side.

Parking Brakes

Under the Motor Vehicles Regulations (Construction and Use), dated March 24th, 1937, every motor vehicle shall be equipped with a braking system (which may be one of the braking systems hereinafter prescribed) so designed and constructed that it can at all times be set so as effectually

to prevent two at least, or in the case of a vehicle with only three wheels one of the wheels from revolving when the vehicle is not being driven or is left unattended:

This Regulation does not apply to:

(i) motor bicycles with or without sidecars attached;
(ii) invalid carriages; or
(iii) land locomotives registered on or before January 1st, 1932.

Petrol Storage Regulations

The conditions governing the storage of petrol are ably summarised as follows:

(1) Differences in conditions governing sale and private storage. (2) Licence. (3) Appeals. (4) Home Office Regulations. (5) Inspection Powers. (6) Official Tests. (7) Labelling. (8) Dealer's Licence. (9) Penalties. (10) Exhibition of conditions under the Act of 1928. (11) Accidents. (12) Pumps. (13) Conveyance.

(1) The trader should recollect that he and his customer stand differently as to the legal provisions. If the customer asks for advice, he must be recommended to get a copy of the Home Secretary's Regulations, under which the private motorist can store petrol without licence. These regulations do not apply when petrol is stocked for sale (except certain of them). Copies can be obtained from H.M. Stationery Office, Kingsway, W.C.2. The official reference to them is "Statutory Rules and Orders (1929) No. 952."

(2) The trader selling petrol must obtain a storage licence under the Petroleum Act of 1928, on application to the local inspector appointed by the local authority.

After the application an official will usually call and inspect the storage facilities, and either require alteration or pass them, and the licence will be granted subject to conditions endorsed.

The maximum fee chargeable by the council is:

In respect of a licence to keep a quantity:

Not exceeding	100 gallons		5s.
Exceeding	100 gallons, not exceeding	500 gallons	10s.
,,	500 ,, ,, ,,	1,000 ,,	15s.
,,	1,000 ,, ,, ,,	5,000 ,,	£1.
,,	5,000 ,, ,, ,,	10,000 ,,	£2.
,,	10,000 ,, ,, ,,	20,000 ,,	£3.
,,	20,000 ,, ,, ,,	50,000 ,,	£4.
,,	50,000		£5.

Note.—In the case of a solid substance for which, by virtue of an Order in Council made under Section 14 of the Act, a licence is required to be granted under the said Act, the fee payable under this Schedule shall be calculated as if ten pounds' weight of the substance were equivalent to one gallon.

3. Sometimes the inspector is unduly harassing in his requirements as to the storage arrangements, and if so, an appeal from the refusal of a licence can be made to the Home Secretary. An appeal is simple and free from expense and risk of costs. The course to be pursued is, first, to demand from the local authority a certificate of the grounds of refusal, which they are bound to furnish, and then within ten days to send the same, with the memorial of appeal, to the Secretary of State.

4. The effect of Regulation No. 1 as to trade sales is to render the trader liable to observe Sections 1 to 9 of the Petroleum Act, 1928, *and also* any conditions endorsed on his licence. The points of Sections 1 to 9 are:

(1) Quantities must be as per licence.
(2) Trader must exhibit posted-up conditions (*see* No. 10, below).
(3) Trader may appeal to Home Secretary against unreasonable conditions.
(4) Licence fees must be paid.
(5) Vessels must be labelled (or a notice displayed near) with the words "Petroleum Spirit" and "Highly Inflammable."
(6) Special regulations of Home Office must be observed as to sending petrol away by road.

(7, 8 and 9) These deal with shipping and harbours and are not of general trade interest.

Manufacturers who do not want to sell, but want to keep more than sixty gallons in a storehouse, on their premises, have to apply for a licence, as the Home Secretary's Regulations state sixty gallons as the maximum per storehouse.

5. (*a*) By Section 17 of the Act of 1928, an officer authorised by the local Council can require the trader to show him his store, and allow him to purchase samples for testing.

(*b*) Further, where a manufacturer is storing under Home Office Regulations as above mentioned, and his storehouse is within twenty feet of another building or inflammable material, the officer of the local authority may inspect at any time, and without production of authority.

(*c*) Under Section 18 of the Act, if anything is suspected to be wrong, the officer can apply to the magistrates for a search warrant, and under such a warrant practically go and see whatever he likes on the premises.

6. Should a sample be taken for testing (and it is well to note that this is the test prescribed to ascertain whether the liquid gives off inflammable vapour at seventy-three degrees F.), the test to be as set out in the Schedule to the Act.

7. Petrol stocked for sale under licence must have attached to each vessel containing it a label (no sort specified as in the case of private storage, when the label must be metallic or enamelled), stating in conspicuous characters "Petroleum Spirit" and the words "highly inflammable"; the name and address of the vendor. Any vessel containing petrol not so labelled can be forfeited, and the trader fined in respect thereof.

There is provision in the Act for small storage (three gallons total) without licence free from the Home Office Regulations, but this probably does not interest the ordinary trader.

8. The Revenue petrol *dealer's* licence is now abolished, but *not* the storage licence mentioned in (2).

9. The penalty for keeping petroleum without a licence is £20 per day, and the forfeiture of all petroleum and vessels; but in most cases (practically speaking) this must be almost obsolete, inasmuch as if petroleum is being kept without a licence, the party by claiming that it is kept under the Home Secretary's Regulations can put the prosecuting officials to the course of proceeding against him for breach of such regulations, on which the fine is £10 maximum. (*See* Godfrey *v.* Napier, 18 *Law Times* Reports, page 32.) And by the Petroleum Act, 1928, the fine (maximum) for breaking any condition of licence is also £20.

10. By the same Act (1928) it is provided:

Where conditions to be observed by persons employed are attached to any licence, the occupier of the premises shall cause to be kept posted on the premises in such form and in such position as to be easily read by the persons employed on the premises a notice setting out those conditions, and—

(*a*) If the occupier of any premises fails to comply with the foregoing requirements of this subsection he shall be liable on summary conviction to a fine not exceeding five pounds for each day on which the ailure continues; and

(*b*) If any person pulls down, injures, or defaces any notice posted in accordance with the requirements of this subsection he shall for each offence be liable on summary conviction to a fine not exceeding five pounds; and

(*c*) If any person employed contravenes any condition of which notice has been given in accordance with the requirements of this subsection he shall for each offence be liable on summary conviction to a fine not exceeding five pounds.

11. Notice of any accident occasioning loss of life or personal injury connected with petrol must be sent at once to the Home Secretary (fine for default, £20).

12. Pumps now being measuring instruments under the Weights and Measures Acts, the Regulations in the Appendix on this subject should be consulted.

13. Regulations governing the conveyance of petrol in tank-wagons have been prepared. It is laid down that the capacity of a tank-wagon shall not, in any case, exceed 2,500 gallons, nor shall the capacity exceed 1,500 gallons unless the design of the vehicle shall have been approved by the Secretary of State. The capacity of a tank-trailer shall not exceed 800 gallons, and no trailer shall be attached to a tank-wagon of greater capacity than 1,500 gallons.

Pneumatic Tyres

The official definition of a pneumatic tyre is a tyre which complies in all respects with the following requirements:

(i) it shall be provided with a continuous closed chamber containing air at a pressure substantially exceeding atmospheric pressure when the tyre is in the condition in which it is normally used, but is not subjected to any load;

(ii) it shall be capable of being inflated and deflated without removal from the wheel or vehicle;
(iii) it shall be such, that when it is deflated and is subjected to a normal load, the sides of the tyre collapse.

Further, *a tyre of soft or elastic material* must either be—

(i) continuous round the circumference of the wheel, or
(ii) fitted in sections so that so far as reasonably practicable no space is left between the ends thereof,

and is of such thickness and design as to minimise, so far as reasonably possible, vibration when the vehicle is in motion, and so constructed as to be free from any defect which might in any way cause damage to the surface of a road.

All the wheels of a motor car, the unladen weight of which exceeds one ton, shall be equipped with pneumatic tyres.

This Regulation did not apply until January 1st, 1940, to any motor car registered on or before January 2nd, 1933, if the vehicle was equipped with tyres of soft or elastic material.

Limiting Dimensions. Motor Cars

Under the provisions of the Motor Vehicles Regulations (Construction and Use), dated March 24th, 1937:

(1) The overall width of a motor car which is used as a public service vehicle shall not exceed 7 ft. 6 in.

(2) Except that the overall width of a motor car shall not exceed 7 ft. 2 in.

The overhang of a motor car shall not exceed 50 per cent. of the distance between the plane perpendicular to the longitudinal axis of the vehicle which passes through the centre or centres of the front wheel or wheels and the foremost vertical plane from which the overhang is to be measured in a specified manner.

Provided that:

(i) in the case of a motor car registered before October 1st, 1938, it shall be sufficient compliance with this Regulation if the overhang does not exceed 7/24ths of the overall length of the vehicle;
(ii) this Regulation shall not apply to a motor car registered on or before January 2nd, 1933;
(iii) this Regulation shall not apply to a motor car designed for use and used by or on behalf of a local authority solely in connection with street cleansing, the collection or disposal of refuse, or the collection or disposal of the contents of gullies or cesspools; and
(iv) in the case of a motor car not exceeding 20 ft. in overall length, the overhang may be increased by not more than 9 in., but shall in no case exceed 7/24ths of the overall length.

Racing and Speed Trials

No racing, competition, or speed trials are allowed, by law, on public highways in this country. Severe penalties are liable to be incurred for promoting or taking part in such trials.

Records of Hours, Journeys, Loads, etc.

Under the provisions of the Road and Rail Traffic Act, 1933, now in force, the holder of a Goods Vehicle Licence, A, B, or C, is required to keep

records of the hours of work of his drivers, the hours of journeys of licensed vehicles, the greatest loads carried, and particulars of the journey. These records must be properly kept and open to the inspection of authorised persons.

Reversing

All motor vehicles (including three-wheelers over 8 cwt. in unladen weight) must be fitted with a reversing gear. Motor vehicles must not be allowed to travel backwards for a greater distance than is requisite for the safety or reasonable convenience of the occupants or other traffic. A number of cases have occurred in which drivers have been fined for driving excessive distances in reverse gear.

Reversing Lights

Reversing white lights at the rear of a motor car are, with certain requirements concerning their usage, now legalised (1954).

Safety Glass

According to the Motor Vehicles Regulations (Construction and Use) of March 24th, 1937, the glass of windscreens and windows facing to the front on the outside of any motor vehicle, except glass fitted to the upper deck of a double-decked vehicle, shall be of safety glass.

For the purposes of this Regulation any windscreen or window at the front of the vehicle the inner surface of which is at an angle exceeding 30 degrees to the longitudinal axis of the vehicle shall be deemed to face to the front. Safety glass is defined as glass so constructed that if it is fractured it does not fly into fragments capable of causing severe cuts.

Servo Braking System

Under the Motor Vehicles Regulations (Construction and Use), dated March 24th, 1937, every motor vehicle registered on or after October 1st, 1937, and as from October 1st, 1942, which is fitted with a servo braking system which embodies a vacuum or pressure reservoir or reservoirs shall be provided with a warning device so placed as to be readily visible to the driver of the vehicle when in the driving seat in order to indicate any impending failure or deficiency in the vacuum or pressure system.

Silencer

It is laid down in an official Regulation that a motor vehicle must be so constructed that the exhaust gases from the engine cannot escape into the atmosphere without first passing through a silencer, expansion chamber, or other contrivance, suitable and sufficient for reducing as far as may reasonably be possible the noise that would otherwise be caused by the escape of these gases.

Smoke

It is now an offence for a motor vehicle to emit an excessive amount of smoke likely to be an annoyance or source of inconvenience to other road users.

Speed Indicators

Under the Motor Vehicles Regulations (Construction and Use), dated March 24th, 1937, to every motor vehicle, registered for the first time on or after October 1st, 1937, other than an invalid carriage or a vehicle which is at all times unlawful to drive at a speed exceeding 12 miles per hour, there shall be fitted an instrument so constructed and in such position as at all times readily to indicate to the driver of the vehicle within a margin of accuracy of plus or minus 10 per cent. if and when he is driving at a speed in excess of that specified in paragraph (2) hereof.

(2) The speed to which reference is made in paragraph (1) hereof shall be such speed as is specified in the First Schedule to the Road Traffic Act, 1934, as the maximum speed for the vehicle to which the instrument aforesaid is fitted in compliance with this Regulation, or if no such speed is prescribed, 30 miles per hour:

Provided that when, by reason of the fact that a vehicle to which this Regulation applies is drawing a trailer or trailers the maximum speed at which it is lawful to drive such vehicle is lower than the speed at which it is lawful to drive such vehicle without such trailer or trailers, the instrument aforesaid shall not be required to indicate such lower speed.

An efficient speedometer must be fitted to every public service vehicle used as an express carriage.

Speed Limits

There is now no maximum speed limit for private motor cars, three-wheelers, and motor cycles,[1] but in the case of passenger vehicles, locomotives, and motor tractors special maximum speed limits are as follows:

1. *Heavy Motor Cars*, carrying more than 7 persons exclusive of the driver	30 m.p.h.
Passenger vehicles drawing a two-wheeled trailer, all wheels having pneumatic tyres	30 ,,
In any other case (including invalid carriages)	20 ,,
2. *Goods Vehicles*, that is to say vehicles constructed or adapted for use for the conveyance of goods of burden of any description:	
(1) When not drawing a trailer—	
(*a*) Motor cars, if all the wheels are fitted with pneumatic tyres; and	
(*b*) Heavy motor cars, constructed or adapted for the conveyance of horses and their attendants and used solely for that purpose, if all the wheels are fitted with pneumatic tyres	30 ,,
(*c*) (i) Motor cars, if all wheels not fitted with pneumatic tyres but are fitted with soft or elastic tyres; and	
(ii) Heavy motor cars (over 2½ tons) if all wheels fitted with pneumatic tyres	20 ,,
(*d*) Heavy motor cars, if all wheels are not fitted with pneumatic tyres but are fitted with soft or elastic tyres	16 ,,

[1] Except when used in built-up areas (see page 463).

(2) When drawing a trailer—
(a) if all wheels both of drawing vehicle and of trailer fitted with pneumatic tyres, or if the trailer is attached to the drawing vehicle by partial superimposition so as to cause a substantial part of weight to be borne by the vehicle and all wheels fitted with soft or elastic tyres . . 16 m.p.h.
(b) if all wheels both of the drawing vehicle and of the trailer are not fitted with pneumatic tyres but are fitted with soft or elastic tyres . . 8 ,,
(3) In any other case . . . . 5 ,,

3. *Locomotives and motor tractors:*
(1) Heavy locomotives (i.e. over $11\frac{1}{2}$ tons, non-goods carrying):
(a) Within any city, town, or village . . . . 3 ,,
(b) Elsewhere . . . . 5 ,,
(2) Light locomotives (i.e. between $7\frac{1}{4}$ and $11\frac{1}{2}$ tons, non-goods carrying): .
(a) When not drawing more than two trailers, if all the wheels both of the locomotive and trailer fitted with soft or elastic tyres . . . 8 ,,
(b) In any other case . . . . 5 ,,
(3) Motor tractors (i.e. not exceeding $7\frac{1}{4}$ tons themselves non-goods carrying):
(a) When not drawing trailer, and all wheels soft or pneumatic tyres . 16 ,,
(b) When drawing trailer—and all wheels (of tractor and trailer) so shod 8 ,,
(c) In any other case . . . . 3 ,,

Speed-limit Discs

From October 1st, 1937, it became compulsory on all vehicles, other than invalid carriages and vehicles not drawing a trailer, which are legally restricted to a speed limit of 20 miles an hour, to exhibit in a conspicuous place at the rear a disc of not less than 8 in. diameter, facing rearwards and having the figures "20" painted in white on a black background. Each figure must be $3\frac{1}{2}$ in. high and $2\frac{1}{2}$ in. wide; the width of every part of each figure is to be $\frac{5}{8}$ in.

Towing

A tow-rope or chain must not exceed in length that which leaves more than 15 ft. between the vehicles; it must be easily visible. In the case of a disabled vehicle towing is allowed on a limited trade plate, if the vehicle is proceeding from the place of disablement to the place of repair or storage.

Trade Number Plates

Two classes of trade number-plate licences are available, viz. the *general* and the *limited* ones. In each case there are two forms of licence, one for all classes of vehicles, including motor cycles, and one for motor cycles and invalid carriages.

General licences for all vehicles cost £25 per annum (or £6 17*s.* 6*d.* quarterly).

For motor cycles and invalid carriages only, the general licence fee is £5 per annum. A general licence can be surrendered and a rebate obtained equal to each complete month unexpired, less 5*s.*

In the case of limited licences these can only be taken out for twelve months, the duties being as follows: (1) All motor vehicles, £5; (2) motor cycles and invalid carriages, £1.

Trade number plates and licence holders are obtainable from county and borough councils.

The front and rear number plates are supplied by the registration authorities and must be returned on expiry of the licence period unless a renewal fee has been paid. A licence card is issued with each trade number and must be carried in the space provided on the plate which is attached to the front of the machine. General licence plates have the border, figures, and letters in white, on a red background. Limited plates have a white background with border, figures, and letters in red.

In all cases it must be remembered that the payment of a single licence fee only entitles a manufacturer or trader to have *one* vehicle on the road *at a time*, and that if it is desired to have two or more vehicles under test or trial at one and the same time, an additional licence in respect of each set of plates must first be taken out.

The holder of a full or " limited " general trade licence and plates for cars can demand also plates for motor cycles without further charge if, in fact, he needs them.

Much misunderstanding has arisen, and many traders fined, owing to an announcement that the full general plate (£25) could be used for *any* purpose. This is not so. It must be used for a purpose in *connection with the trader's business of a motor manufacturer, dealer, or repairer.*

Particulars of the respective uses to which limited licences can be put are given in Regulation No. 30 of the 1924 Road Vehicles (Registration and Licensing) Regulations.

Trailers

A motor car carrying not more than seven passengers with a trailer of not more than two wheels is limited to 30 m.p.h.

For any other type of trailer the speed limit is 20 m.p.h.

A heavy motor car, and also a motor-car for eight or more passengers, with trailer has a speed limit of 20 m.p.h.

A trailer must have a red rear light, but it is unnecessary to have one on the drawing vehicle as well, unless the distance between the two units is more than 5 ft.

The trailer must carry the rear number plate of the drawing vehicle.

In 1954 the earlier regulations regarding special " T " plates, known as Trailer Plates, were amended, and it became compulsory for trailers to carry a rear plate of triangular shape, of a minimum side length of 6 in., excluding corner radii, containing nine separate red reflectors on a white background.

Tyres, Condition of

All tyres used on motor vehicles must be kept in such a condition as not to cause damage to the road or danger to any person.

Tyres for Motor Vehicles

(*a*) **Locomotives.**—All tyres must be of soft or elastic material extending continuously around each wheel or fitted in sections provided that:

(1) At no point shall any section of the material be separated by more than $\frac{3}{4}$ in. from any adjacent section. (2) The aggregate extent of all spaces between sections of the material of any wheel measured along any line taken round the outer surface of the tyre and parallel to its edge shall not exceed 6 in.

These provisions will not apply to a land locomotive if the following conditions are observed:

(i) the tyres of all steering wheels shall be smooth-soled and where the tyres touch the surface of the road they shall not be less than 5 in. in width.

(ii) the tyres of all driving wheels shall not be less than 12 in. in width, shall be smooth-soled or shod with diagonal cross-bars of not less than 3 in. in width, nor more than $\frac{3}{4}$ in. in thickness, extending the full breadth of the tyre and so arranged that the space intervening between each pair of cross-bars shall not exceed 3 in.

(*b*) **Motor Tractors.**—The tyres must be of soft or elastic material, but this did not apply until January 1st, 1933, to a tractor registered on or before January 1st, 1932. A land tractor is exempt from this provision if it complies with the following conditions:

(*a*) the tyre of each steering wheel shall be smooth-soled and where the tyre touches the surface of the road it shall be not less than $2\frac{1}{2}$ in. in width;

(*b*) the tyre of each driving wheel shall be not less than 6 in. in width, smooth-soled or shod with diagonal cross-bars of not less than 3 in. in width, nor more than $\frac{3}{4}$ in. in thickness extending the full breadth of the tyre and so arranged that the space between each pair of cross-bars shall not exceed 3 in.

(*c*) **Heavy Motor Cars** (*and motor cars not exceeding one ton unladen weight*).—Tyres must be pneumatic. This requirement did not apply until January 1st, 1940, to a vehicle registered under the Road Act, 1920, on or before January 1st, 1933, if it was equipped with tyres of soft or elastic material.

This requirement also does not apply to (*a*) heavy motor vehicles exceeding four tons in unladen weight mainly used on rough ground or unmade roads; (*b*) vehicles designed and used by or on behalf of local authorities for street cleansing and removal of refuse; (*c*) turntable fire escapes or tower wagons; (*d*) specially designed motor cars under 30 cwt. used on roads only between works and premises in immediate vicinity.

Trailers drawn by a motor car or heavy motor car must have pneumatic tyres. Exemptions are made in the case of works' trucks, special municipal vehicles, water carts, and trailers drawn by road rollers.

Tyres fitted to any wheel of a heavy motor car must not be of greater nominal section than that indicated on the appropriate wheel plate.

Unauthorised Towing

It is a legal offence to take hold of, or to get on, a motor vehicle while in motion on the road for the purpose of being drawn or carried, without lawful authority or reasonable cause.

Unauthorised Tampering

It is an offence to tamper with the brake or any other part of its mechanism without lawful authority or reasonable cause.

Unladen Weight

The official interpretation of unladen weight is the weight of the vehicle, including the body and all parts (the heavier being taken where alternative bodies or parts are used) which are necessary to, or ordinarily used with, the vehicle when working on the road, but exclusive of the weight of water, fuel, or batteries used for the purpose of the supply of power for the propulsion of the vehicle, and of loose tools and loose equipment.

View to the Front

Under the Motor Vehicles Regulations (Construction and Use), dated March 24th, 1937, every motor vehicle shall be so designed and constructed that the driver thereof while controlling the vehicle can at all times have a full view of the road and traffic ahead of the motor vehicle.

Warning Instruments

According to the Motor Vehicles Regulations (Construction and Use), issued March 24th, 1937, every motor vehicle other than a locomotive or a land tractor shall be fitted with an instrument capable of giving audible and sufficient warning of its approach or position:

It is stipulated that no instrument shall consist of—

(i) a gong or bell, except in the case of a motor vehicle used solely for fire brigade, ambulance, salvage corps, or police purposes; or

(ii) a siren, except in the case of a vehicle used solely for fire brigade, salvage corps, or police purposes.

(See also " Horn " on page 438.)

Weights of Vehicles

Any person authorised by a Highway Authority or a police constable duly authorised may, on production of his authority, require the person in charge of a motor vehicle to allow the vehicle to be weighed; the same applies to a trailer used with a motor vehicle.

The maximum permissible weights of the various classes of motor vehicles are laid down in the Motor Vehicles Construction and Use Regulations, 1931.

Briefly the maximum permissible weights are as follows:

(1) Locomotives, $15\frac{1}{2}$ tons.
    ,, equipped with soft or elastic tyres, 17 tons.
(2) Trailers drawn by locomotives, 40 tons.
(3) Heavy motor cars, with four wheels, $7\frac{1}{4}$ tons.
    ,, ,, ,, ,, six ,, 10 tons.
    ,, ,, ,, ,, more than six wheels, 11 tons.

The laden weight transmitted to the road surface by any wheel of a heavy motor car where no other wheel is in the same line transversely must not exceed 4 tons, and the weight transmitted by any two wheels in

line, 8 tons for a four-wheeled vehicle and $7\frac{1}{2}$ tons for one with more than four wheels.

The sum of the weights transmitted to the road by all the wheels must not exceed (*a*) in the case of a vehicle with four wheels, 12 tons, (*b*) six wheels, 19 tons, and (*c*) more than six wheels, 22 tons.

The total weight transmitted to the road surface by any two wheels of a trailer in line transversely must not exceed $6\frac{1}{2}$ tons. Where a two-wheeled trailer forms part of an articulated vehicle, the weight transmitted to the road by the wheels thereof may equal, but shall not exceed, 8 tons if all the wheels of the articulated vehicle are fitted with pneumatic tyres and the total weight transmitted to the road by all the wheels does not exceed 19 tons.

The total weight of a heavy motor car, together with its load, and the total weight of any trailer together with its load, shall at all times be such and so distributed that the weight transmitted to any strip of the surface upon which the vehicle rests, contained between any two parallel lines drawn 2 ft. apart on that surface at right angles to the longitudinal axis of the vehicle, shall not exceed 10 tons.

Windscreens[1]

All windscreens facing to the front or the outside of any motor vehicle, including sidecars, three- and four-wheelers, must be fitted with safety glass, or clear celluloid or cellulose sheet.

The safety glass must be maintained in a satisfactory condition so as not to obscure the driver's vision.

Motor-cycle windscreens for solo purposes come under this regulation.

In the case of certain makes of safety glass, in which there is a central layer of celluloid or cellulose, cemented with a transparent material between two plates of glass, if the cement fails there is a discoloration effect which in some cases may be construed as an obstruction to the driver's vision.

Windscreen Wipers

It is laid down in the Motor Vehicles Regulations (Construction and Use), issued March 24th, 1937, that as from October 1st, 1937, an efficient automatic windscreen wiper shall be fitted to every vehicle which is so constructed that the driver cannot, by opening the windscreen or otherwise, obtain an adequate view to the front of the vehicle without looking through the windscreen.

Wings, or Mudguards

Except in cases where adequate protection is afforded by the body, every motor vehicle, including motor cycles, must be provided with suitable

[1] See also "Safety Glass," page 454.

means of preventing mud or water from being thrown off the wheels on to other road users. Thus it is an offence to drive a motor vehicle on wet or muddy roads without proper mudguards or some equivalent devices.

These regulations do not apply to a vehicle in an unfinished condition proceeding to a works for completion.

Trailers must also have wings on the rear wheels.

There are certain exemptions, viz. in the case of timber trailers, living vans, water carts, fire pumps, and trailers drawn by vehicles restricted to 12 m.p.h.

Wireless Receiver in Motor Car

Whilst the owner of a domestic wireless receiver is also permitted the use of a portable receiver in his house, garden or occasionally in his motor car, it is not legal to fit a portable set permanently in a motor car, unless an additional fee of £1, annually, is paid. The same fee applies also to other types of wireless sets fitted permanently in motor vehicles.

Garage Responsibilities

The following are some of the principal points affecting garage proprietors:

(*a*) **Workmen.**—The proprietor is responsible for the safety of his employees, and he should therefore take every reasonable precaution to prevent accidents. Further, since there is always the possibility, in the event of accidents, of the servant making a claim, either under the *Employer's Liability Act of* 1880, or the *Workmen's Compensation Act of* 1906, the master should insure himself with one of the leading Insurance Companies against this risk.

Further, he should make himself familiar with the provisions of the Factory Act as regards the working conditions in his workshops; there are certain safety and sanitary precautions which must be observed; particulars of these can be obtained from the local Factory Inspector.

The proprietor should see that the National Health and Unemployment Insurance contributions are paid for chauffeurs and other employees coming within the scope of the Act.

(*b*) **Storing of Cars.**—When a garage or any other proprietor undertakes for a fee to garage a client's car, he is legally compelled to look after the car and is liable for any injuries caused to the car in the owner's absence, or not due to the owner's negligence. He must take all reasonable precautions to prevent injury, whether mechanical, or by fire or damp. If any harm is caused to the car, it is assumed in law that the proprietor is responsible, and he must therefore, in defence, endeavour to prove that he took every reasonable care to avoid damage.

Although many garage proprietors now issue Garage Tickets when cars are deposited, and on these tickets disclaim any responsibility for fire, theft and accidental damage other than by the wilful act of the proprietor

or his employees, it should be made quite clear that the fact of the garage proprietor accepting a fee for garaging the car places an onus upon him, and he is liable for all damage caused unless he can prove that the cause of the damage is outside the scope of his liability.

It is advisable for the garage proprietor, before accepting a car, to make a note of and bring to the driver's notice any existing damage, such as scratched paintwork, dented mudguards, and the like.

Similarly, it is advisable to indicate to the car owner that any contents of the car, e.g. rugs, clothes, bags, and books, should be removed or deposited in the office. In the ordinary way the garage proprietor is legally responsible in cases of theft from the car, unless he can prove that he took every reasonable precaution against theft, or made certain reservations of liability.

If a client arranges with a garage proprietor to store, or house, his car, and if for any reason the latter finds that he has no room for it, he is legally responsible for any damage caused to the car by exposure, or any loss or injuries caused in any other garage which he has taken or sent it to.

(*c*) **Cars under Repair.**—The same legal obligations hold in the case of cars undergoing repairs as for housing; the garage proprietor is responsible for the safety and condition of the car all the time it is in his hands.

Garage repairs are assumed by law, in common with other crafts, to be carried out with the usual skill and mechanical knowledge, and the proprietor is, therefore, responsible for the consequences of bad work, accidents through faulty repairs, etc. If the proprietor, for any reason other than that of the client's obstruction, fails to carry out his contract with the car owner for repairs, adjustments, etc., he cannot claim any payment before the work is done; that is to say, he cannot ask for something on account. Moreover, if there was an agreed time limit, the car owner may claim damages for loss of business and any other loss due to delay.

(*d*) **Lien on Car.**—It is a generally accepted point of law that the garage proprietor has a lien upon any vehicle accepted for repair; the same thing applies to goods supplied, such as tyres, oil, or petrol, whilst the vehicle is in the garage. It is important to observe that unless the owner authorises the repairs, a lien cannot be had on the car. If, for example, some other person gave the instructions, and had no authority from the owner, the latter would not be responsible. There is no lien in the case of a car left at a garage for housing or even maintenance; the latter implies only a specially careful housing. An owner is legally free to obtain access to and take his car away from a garage at any reasonable time, even if the rent has not been paid. It is always advisable for garage proprietors to make proper agreements in respect to contracts entered into with their clients for the storing, maintenance, or repairs to motor vehicles. For this purpose special forms of contract have been drawn up by A. C. Crane, and are obtainable from the Trader Publishing Co., Dorset House, Stamford Street, London, S.E.1.

In respect to the general responsibilities of garage proprietors it is usual, where the latter wish to limit their responsibilities, to insert clauses in their contracts, i.e. Garage Tickets, and to see that these are brought to their clients' notice. Thus they may state that " Acceptance of a Car " for housing, maintenance, or repairs is " *subject to the conditions printed herewith*," or, in the case of a Garage Ticket, " *on the back of this ticket*."

Speed Limit in Restricted Area

According to existing official regulations no vehicle, whether limited or unlimited as to road speed, may proceed at a speed of more than 30 miles per hour in a built-up area, where the street lamps are 200 yards or less apart, unless this area is derestricted by suitable road signs. At the entrance to each restricted area a " 30 m.p.h." sign of circular form is erected by the road authorities and at the exit (as viewed by the driver of the car) a cancellation sign, consisting of a diagonal band on a circular disc, is erected.

Selling Unroadworthy Vehicles

It is an offence under the conditions of the Road Traffic Act of 1934 to sell, offer for sale, or supply a motor vehicle or trailer which is in a condition such that its use on the road would be illegal under Section 3 of the Road Traffic Act of 1930. Exceptions to this regulation are cases where vehicles are to be reconditioned before being put on the road, vehicles to be used on private property only, or those to be exported.

Road-vehicle Regulations (Ministry of Transport)[1]

Road Vehicles (Registration and Licensing) Regulations, 1924 (1*s*.), 1949 (1*s*.).
Road Vehicles (Part-year Licensing) Order, 1924 (1*d*.).
Road Vehicles (Part-year Licensing) Amendment Order, 1928 (1*d*.).
Hackney Motor Vehicles (Seating Capacity) Regulations, 1927 (1*d*.).
Road Vehicles Lighting Regulations, 1936 (2*d*.).
Motor Vehicles (Direction Indicator and Stop Light) Regulations, 1941 (1*d*.).
Road Vehicles Lighting (Special Exemption) Regulations, 1949, 1950 (1*d*. each).
Road Vehicles (Registration and Licensing) Regulations, 1949 (1*d*.).
Motor Vehicles (Driving Licences) Regulations, 1930 (2*s*.), 1934 (9*d*.).
Road and Rail Traffic Act, 1933 (1*s*.).
Road Transport Act, 1947 (3*s*.).
Goods Vehicles (Licences and Prohibitions), 1936 (6*d*.).
Goods Vehicles (Licences and Prohibitions) (Amendment), 1938 (1*d*.).
Goods Vehicles (Licences and Prohibitions) Regulations, 1948 (3*d*.).
Road Vehicles and Drivers Order, 1950 (3*d*.).

[1] Obtainable from H.M. Stationery Office, Kingsway, London, W.C.2.

Goods Vehicles (Duration of Carriers Licences), 1938 (1*d.*).
P.S.V. (Record of Licences) Regulations, 1933 (1*d.*).
P.S.V. (Licences and Certificates) Regulations 1934 (4*d.*).
P.S.V. (Licences and Certificates) Regulations (Amendment), 1939 (1*d.*).
P.S.V. (Duration of Road Service Licences) Regulations, 1937, 1938 (1*d.* each).
Motor Vehicles (Third Party Risks) Regulations, 1930, 1941 (3*d.*), 1949 (1*d.*).
Motor Vehicles (Construction and Use of) Regulations, 1941 (6*d.*).
Motor Vehicles (Construction and Use of) Regulations, 1947 (8*d.*).
P.S.V. (Equipment and Use) Regulations, 1941 (1*d.*).
Road Vehicles and Drivers Order, 1950 (3*d.*).
Road Vehicles and Drivers Order (Amendment), 1950 (1*d.*).
Motor Vehicles (Authorisation of Special Types) General Order, 1941, with various subsequent Amendments from 1941 to 1950 (1*d.* each).
Motor Vehicles (Variation of Speed Limit) Regulations, 1937, 1938, 1947, and 1950 (1*d.* each).
Motor Vehicles (Definition of Motor Cars) Regulations, 1941 (1*d.*).
Motor Vehicles (Gas Propelled Vehicles) Regulations, 1940 (1*d.*).

Taxation of Motor Vehicles

Road Vehicles (Registration and Licensing) Regulations, 1920 (4*d.*) and 1949 (1*s.*).
Vehicles (Excise) Act, 1949 (9*d.*).
Road Vehicles and Drivers Order, 1949 (3*d.*).
Road Vehicles (Past Year Licensing) Order, 1939 (1*d.*).
Cylinder Capacity Duty (Appointed Day) Order, 1946 (1*d.*).

Records, Rates, Changes, Returns

Road and Rail Traffic Act, 1930 (2*s.*).
Road Traffic Act, 1944 (9*d.*).
Goods Vehicles (Keeping of Records) Regulations, 1935 (3*d.*).
Road Haulage and Hire Charges Order, 1942 (1*d.*).
Road Haulage and Hire Charges Order (Amendment), 1946 (1*d.*).
P.S.V. (Contract Carriage Records) Regulations, 1934 (1*d.*).
Road Haulage Undertakings (Accounts and Returns) Order, 1941 (1*d.*).
Motor Vehicles (Returns of Spare Parts, Tyres, etc.) Order, 1941 (1*d.*).
Fuel (Records and Information) Order, 1942 (1*d.*).

Fuel Regulations

Petroleum Spirit (Motor Vehicles) Regulations, 1929 (2*d.*).
Heavy Oils (Road Fuel) Regulations, 1935 (2*d.*).
Hydrocarbon Oils Regulations, 1948 (2*d.*).
Fuel Inspection Order, 1943 (2*d.*).

Drivers' Hours and Labour Regulations

Road Vehicles and Drivers Order, 1950 (3*d.*).
Road Traffic Acts, 1930 (2*s.*), 1934 (9*d.*).
Road and Rail Traffic Act, 1933 (1*s.*).
R.T.A. 1930 (Variation of Provisions) Order, 1934 (1*d.*), 1937 (1*d.*).
Factories Acts, 1937 (2*s.* 6*d.*).
Young Persons Employment Act, 1938 (3*d.*).
Factories (Hours of Employment in Factories Using Electricity) Order, 1947 (2*d.*).
Hours of Work in Factories (Women and Young Persons) Order, 1942 (free).
Conditions of Employment and National Arbitration Order, 1940 (2*d.*), with various subsequent Amendments to 1950 (1*d.* each).

Later Road Vehicle Regulations

Since the last edition of this work was published a number of new Ministry of Transport regulations have come into force, the following being the more important of these regulations:

Motor Vehicles (Construction and Use) Regulations, 1951 (1*s.* 3*d.*).
Motor Vehicles (Construction and Use) (Amendment) Regulations, 1952 (2*d.*).
Motor Vehicles (Construction and Use) (Amendment) Regulations, 1953[1] (6*d.*).
Motor Vehicles (Construction and Use) (Track-laying Vehicles) (Amendment) Regulations, 1953 (4*d.*).
Motor Vehicles (Authorisation of Special Types) General Order, 1952 (9*d.*).
Road Vehicles (Registration and Licensing) Regulations, 1953 (1*s.*).
Road Vehicles (Registration and Licensing) (Amendment) Regulations, 1953 (2*d.*).
Road Vehicles (Transport Levy) Order, 1953 (2*d.*,
Road Vehicles (Transport Levy) Regulations, 1953 (2*d.*).
Road Vehicles (Excise Duty and Licences) Order, 1953 (3*d.*).
Motor Vehicles (International Circulation) (Amendment) Regulations, 1953 (3*d.*).
Motor Vehicles (Third Party Risks Deposits) Rules, 1952.
Public Service Vehicles (Records of Licences) Regulations (Revised to 1954) (6*d.*)
Public Service Vehicles (Lost Property) Regulations, 1954 (4*d.*)
Road Transport Lighting Act, 1953 (3*d.*)
Road Vehicles Lighting Regulations, 1954 (9*d.*).
Road Vehicles Lighting (Reversing Lights) Regulations, 1953 (3*d.*).
Road Vehicles and Drivers Order, 1952 (3*d.*).
Goods Vehicles (Licences and Prohibitions) Regulations, 1952 (3*d.*).
Goods Vehicles (Licences and Prohibitions) (Amendment) Regulations, 1953 (3*d.*).

[1] In force on January 1st, 1954.

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